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Vol. 8, No. 3 MARCH, 1919

THE SCIENTIFIC MONTHLY

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THE SCIENCE PRESS

LANCASTER, PA. GARRISON, N. Y.

NEW YORK: SUB-STATION 84

SINGLE NUMBER, 30 CENTS YEARLY SUBSCRIPTION, $3.00

THE SCIENTIFIC MONTHLY

MARCH, 1919

SOURCES AND TENDENCIES IN AMERICAN GEOLOGY

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AMERICAN leadership in invention and engineering is generally acknowledged, but what is our position in the various fields of science? It has been customary to look to Europe, and, in the last half century, especially to Germany as the leader in scientific achievement. In some lines this is no doubt true, but in other lines it is not true. The present, as the smoke of battle subsides, is an appropriate time to question old traditions now shaken loose before they settle again into fixed ideas. A study should be made of the contributions of the several nationalities both as to quantity and quality of productivity in each field of learning. The results of such a study of the progress of geology are given in this article and the conclusion is reached that for the past generation America, under which name should be included both the United States and Canada, has held a position of world leadership in that science. The order of importance of the other nationalities before the great war, taking the progress of the last half century as a measure, would be second, the British empire; third, Germany; fourth, France; but Italy, Scandinavia and Russia have also made notable contributions. If the place in geology held by the different nations be evaluated for the entire nineteenth century the order, in the opinion of the present writer, would be Great Britain, France, America, Germany; Great Britain being easily the leader.

In approaching this subject at the present time we must of course be careful in weighing the past contributions of Germany not to govern the verdict by the natural tendency to "trample them, they're down." The subject can, however, be tested in part by impersonal standards. Scientists are, as a class, unemotional creatures, and although those of the allied countries

unitedly condemn the criminal acts of the paranoiac among nations, those from whom the writer has secured data have shown a marked freedom from emotional bias. The conclusions expressed in this article are not new with the writer. In July, 1914, he had occasion to discuss the superficiality of the work of several German scientists on a certain geological subject and to point out their ignorance of the fact that English scientists had reached different and far sounder conclusions a generation previously. Yet the prestige of a German professorship had apparently blinded many American readers to obvious trivialities of argument.[1] On the other hand, the work of certain other German geologists should freely be recognized as of the highest grade, and their writings have marked notable advances in thought.

The broad attitude taken by von Zittel in 1899 is to be commended, as expressed in the following quotation:

> Although the present author of the "History of Geology" (von Zittel) was asked to depict chiefly the history of the growth of the science in Germany, the nature of the subject is such that it could not be successfully treated along national lines. All civilized nations have shared in the development of the natural sciences, the history of any one of which must be to a certain extent the history of a scientific freemasonry. The questions of the highest import in geology and paleontology are in no way affected by political frontiers, and the contributions to the progress of these studies made by members of any nationality can only be appreciated in their true values when held in the balance with the general position of research at the time, and with the discoveries and advances made by other geologists irrespective of nationality.[2]

Although the history of a science, as von Zittel states, can not be written with reference to any one nation alone, it is quite possible to recognize the relative contributions of the several nations.

In discussing the subject of the sources and tendencies of American geology, the first question which arises is as to the present content of geology. Every reader will feel sure that he knows what geology is, yet it is safe to say that few, except active geologists, are aware of the present scope of its subject matter and the lines along which research is now being pushed. The value of such a review as this may lie as much in giving a better perspective of the content of geology as in pointing out the relative contributions of different nations.

Popular ideas of a science are apt to lag a generation be-

[1] Joseph Barrell, "The Status of Hypotheses of Polar Wanderings," *Science*, Vol. XL., pp. 333–340, written July, 1914, published September 4, 1914.

[2] Karl A. von Zittel, "Geschichte der Geologie und Paläontologie bis Ende des 19. Jahrhunderts, 1899," English translation, pp. v, vi.

hind the real stage of advancement. In the popular imagination, geology is still supposed to consist largely on the one hand in collecting and naming rocks and fossils, the placing of these in proper sequence, and, on the other hand, theories of a rather speculative and uncertain character on the origin of the earth, its internal nature, and its history. As a matter of fact, there is but little in modern geology at its best which partakes of these characters. It has been said that a science in its growth passes from embryo to adult through the speculative, qualitative, quantitative, to predictive stages of development. Geologic research in the past generation has been passing out of the qualitative stage and has partaken notably of the quantitative character.

Geology, the science of the earth, is exceedingly broad in its scope and has developed into many branches, each of which rests more or less heavily upon some other science. From a division of natural history, whose early workers had little in the way of qualification other than powers of observation, acquisitiveness and a love of life in the open, it has passed into a group of special sciences. The elements of geology can be taught with advantage to students who have had no training in other sciences, being from the cultural standpoint one of the most broadening branches of knowledge, but research in the several fields now requires a thorough grounding in other sciences and such advanced training as is given in graduate schools.

Mineralogy has expanded into petrology. The form, composition and identification of minerals is of less interest than the broader questions which rise out of them. Leading toward physics, the orderly arrangement of the atoms in the crystal has been found to form a diffraction grating incomparably finer in spacing than any which could be made in the laboratory. The physicist, utilizing this, has solved the nature of the X-rays, and in turn this leads to a better knowledge of crystals. On the physico-chemical side, the crystallization of minerals from molten rocks is a problem of mutual solutions at high temperatures and is being investigated in the geo-physical laboratory. On the more strictly geological side, a mineral is a measure of the physical and chemical environment under which it originated. The secondary alterations taken in connection with the limits of stability of a mineral record the subsequent physical history of the rock of which it is a part. Minerals are thus geological thermometers and dynamometers. Their relations to each other, as seen under the microscope, show the order of crystallization; the assemblage, constituting the rock, gives a

definite record of environment and subsequent history. The mapping of rock types over the earth's surface proceeds, and out of it grow studies on differentiation—the changes through geologic time in the nature of molten rocks erupted in the same region. The fundamental relationships found within one region constitute the problems of consanguinity; by contrast, the unlikeness of different regions in earth composition mark out petrographic provinces. What are the meanings of differentiation, consanguinity and petrographic provinces? Such are the larger problems of petrology.

Paleontology, the ancient life history of the earth, was characterized a generation ago by the description and naming of species. There was a keen rivalry for priority and explorations were conducted to obtain new faunas. Almost no attention was paid regarding the associations of the fossil with the nature of the enveloping rocks, and but little to the exact stratigraphic level from which it was taken. To-day, in the hands of leaders, the description of new species is but an incidental task. From a keen study of the fossil, the form and habits of the living animal are inferred. The nature of the rock is used to restore the ancient environment, whether marine or terrestrial, swamp or arid plain. Fossils are collected and recorded foot by foot through a stratigraphic section, permitting the stages in the geographic shifting and geologic advancement of faunas to be followed. The areal limits of a fauna and the geographic distinctions serve as a means of delimiting ancient lands, seas and climatic zones. The study of the changes of life with respect to changes of environment and the passage of time throws valuable light on the causes and character of organic evolution. The perspective over long intervals of time gives a line of attack which is not possible to the student of living animals and plants. Thus the fossil, like the mineral, has become a means to an end;—those ends look toward a knowledge of the thing, a knowledge of its environment, a knowledge of causes and effects through vast periods of time.

Stratigraphy formerly consisted in but little more than measuring the thickness of sedimentary formations and mapping their areal extent. Formations of different regions were correlated by means of fossils and the sequence of the periods established. All sediments were assumed to be deposited in the sea, except such as contained remains of terrestrial organisms and were entirely devoid of those of the sea: such formations were regarded as deposited in lakes, although the fossils were commonly those of land plants and animals. This stage of development is now looked upon as merely having laid a ground-

work for the investigation of broader problems. The interpretation of the mode of origin of the sediments was narrow and conventional. At the present time, by contrast, the terrestrial deposits on broad river flood plains and deltas are seen to constitute an appreciable part of the geological record. Glacial débris in many older formations shows the recurrence of cold since very early geologic periods. At other times beds of salt and gypsum show widespread aridity. Each type of climate and topography is seen to be reflected in the nature of sediments. Through stratigraphy is thus built up the succession of past environments which paleontology peoples with living plants and animals. Between them these branches of geology are re-creating the geography of all the yesterdays, a subject taking form under the names of paleogeography and paleoclimatology.

During the past quarter century structural geology has grown to be a branch of large importance. It comprises several fields. That best known deals with the results of the forces of deformation acting upon older rock masses. Joints, faults, folds, schistosity are the expressions seen in a limited exposure. The merely descriptive stage of investigation is past. The faults must be classified into systems, their displacements ascertained and the position of severed portions of valuable ores located. Folds are analyzed into different orders of magnitude and the determination of the folded structures has led to the opening of iron deposits valued at many millions of dollars. The theories of deformational geology must thus meet the tests of verification and this necessity has stimulated the development of a quantitative accuracy. But this division of structural geology is the smaller part of the field, that dealing with details in the outermost crust. Passing to a larger scale, the nature of mountain structures has been greatly elucidated. In the past twenty years French geologists have given a new interpretation to the Alps based on great horizontally acting overthrusts. Vertical forces, uplifting faulted blocks, or warping upwards tracts which had acquired their mountainous structures long previously are found to be also fundamental as causes of mountain growth. The reasons for the existence of continents and ocean basins and the amount of their changes through geologic time is a still larger field of theory on which only a beginning has been made. Finally, geophysics is that field of structural geology in which precise geodetical and astronomical measurements are throwing light upon the distribution and character of density and rigidity through the crust and the deeper body of the earth. The ultimate causes of earth

structure are thus to be sought through the character of the insensible vibrations from far distant earthquakes and through precise measurements obtained by observations on the stars.

Physiography is a division of the new geology which had only feeble representation in the previous generation. This, the science of the earth's surface, consists of a study of forms and causes. It embraces the effects of surface activities, a field known also as dynamical geology, and seeks through them the causes of the forms of the lands from the smallest to the largest features. In the middle of the last century valleys were still supposed to be determined by rifts and depressions in the crust, although Hutton and Playfair had shown clearly long before that the valleys were carved by running water. The existing mountain ranges were regarded as elevated at the close of the period of the youngest formation entering into their structure and were thought capable of enduring in subdued form through all of geologic time.

The beginning of the present development rested on the recognition that erosion by rain and rivers carried to the limit would result in a surface nearly plane cut across all rock structures and developed near the level of the sea. Davis, thirty years ago, named such an ultimate land form a peneplain. Distinguished by a name, they were then recognized, though now uplifted and in various stages of destruction, in many mountain regions. A new means had been found of studying mountain history. Uplift initiates a new cycle of erosion with respect to a new baselevel. Applying this principle, a landscape is now interpreted as but one stage in a sequence of forms, passing from some initial stage of uplift toward a featureless plain of erosion lying at the level of the sea. Geologic time is seen to be so long in comparison with the time needed to level the loftiest mountain range that folding and uplift must have occurred again and again since the earliest ages in order to provide sources for the sediments which have built up the stratigraphic series. The present upland and valley forms show in every continent from the youth or early maturity of the present erosion cycles that the world is girdled with very young mountains, even where their rocks and structures are very ancient. The present geologic period is consequently seen to be one of profound terrestrial revolution, a conclusion of high importance in our understanding of the earth and the relations of man to his dwelling place and the causes which gave him birth.

Lastly there has grown to high importance the branch of economic geology. This was formerly regarded as consisting in a description of ore deposits and building materials accom-

panied with statistics of production. That original field has become only one section of the subject. Economic geology has recently been defined by the director of the United States Geological Survey as "useful geology." Another definition expressive of its content and purpose is that economic geology is applied geology. Pure science, the search for new knowledge for its own sake and without thought of its applications, becomes applied science in the most unexpected ways. Every division of geology has contributed to the advancement and expansion of economic geology. Petrologic and chemical geology, stratigraphy and physiography, all lead to the study and conservation of soils, the basis of agricultural wealth. The working out of stratigraphy and structure permits intelligent search for the stores of underground water, the most valuable of minerals in many parts of the national domain. A knowledge of the structure and character of the foundation rocks can be given by the geologist to the engineer and military chief, of great importance toward the success of foundations, dams, roads, canals and military works. A knowledge of stratigraphy and structure has led to the discovery of coal basins concealed beneath younger strata. Hundreds of young geologists are now being employed by the great petroleum companies to study the stratigraphy and structure mile by mile over great areas of country in the search for mineral oil. Mining geologists are now retained permanently on the staffs of many large companies to study and map in detail the relations of complex ore deposits as a guide to more intelligent development in mining. Physiography also is making its contribution to the location of copper, manganese, and other deposits; since where these have been concentrated through the agency of circulating underground waters the recognition of the former stages of erosion serve as a guide to present location. Other geologists are employed on state and national surveys, classifying lands, discovering and mapping the areas of valuable deposits such as coal, iron, potash, and phosphates for the benefit, now and in the future, of all the people of the nation. A higher field of economic geology is that of the conservation of national wealth. It is not an overstatement to say that the future welfare of mankind through unnumbered centuries yet to come depends upon the spread of education in regard to the limitations of mineral wealth and the development in the national consciousness of the creed that each generation holds the treasures of the earth in trust for the future, to be used but not squandered by the temporary trustees.

Let us turn from this survey of the present viewpoints of

geology to a review of its growth and note whence have come the fundamental ideas which from generation to generation have expanded its fields of theory and usefulness.

Speculations on the origin and history of the earth once formed a favorite theme for philosophers. Omitting from consideration the ancients, such men as Descartes and Leibnitz devised theories of cosmogony which represented advances in thought; but such systems of philosophy, not founded on field observation and inductive reasoning should be sharply distinguished from the science of geology. A science rests upon careful observation, classification of observations, framing of hypotheses to relate the facts to each other, and testing of the hypotheses by further observations. There must be both induction and deduction, for the groundwork of geology to justify its name must rest on a patient study of the earth. The grand schemes of the cosmogonists, notwithstanding their stimulation to thought, perhaps served more to retard than to aid the development of real science. In the latter half of the eighteenth century geology became firmly established on a groundwork of fact as a result of the labors of a few men in France, Italy, Germany and Great Britain, of whom the philosophers took no recognition. Guettard, Demarest, Arduino, Lehmann, Füchsel, Smith and Hutton are the men who stand forth, but the greatest of these was Hutton.

Hutton, regarded as the founder of modern geology, was born in Edinburgh in 1726 and died there in 1797. He held no university position but pursued his investigations solely from their inherent interest. He did not publish his views until 1785, and beyond the circle of his friends they attracted little attention until after Playfair in 1802 published his classic volume, "The Huttonian Theory of the Earth," in which he condensed and clarified the work of his friend into much more readable form. Hutton saw the evidence that the great masses of granite which so commonly underlie the stratified rocks had originated by crystallization from a melted state and had risen in molten form into the outer crust from the depths of the earth. The folding, upturning, mashing and crystallizing of the sedimentary rocks he saw was due to the vast forces within the crust aided by internal heat. Great crust revolutions resulting in the uplift of mountains were followed by prolonged weathering and erosion of all rocks above the level of the sea. New sedimentary formations from the débris of other lands were then laid down across the eroded edges of the rock formations of an older world. The forces now in operation he held were capable through unlimited time of effecting these stupen-

dous results, time and time again. Back of each older world were the ruins of a world still older. In Hutton's words, "we find no vestige of a beginning—no prospect of an end."

These magnificent conceptions were not cosmogonic speculations, but were founded on close and prolonged observations. They were generalizations which had been seldom glimpsed and never before clearly seen or proved through two thousand years of intellectual endeavor. Because the Huttonian theory of the earth was distinguished by giving an important place to the heat and deforming forces of the inner earth, those who accepted Hutton's ideas were called Plutonists.

Twenty-three years later than Hutton the mineralogist Werner was born in Prussian Silesia. In 1775, at the age of twenty-six he was appointed inspector and teacher of mining and mineralogy in the Freiberg Mining Academy. For forty-two years he continued in this position and was throughout that time enthusiastically regarded by those who listened to his lectures as an oracle on the history and rock formations of the entire earth. To this subject he gave the name of geognosy and his students went forth with the fervor of disciples to spread his doctrines. With a personal knowledge limited to Saxony and Silesia he nevertheless advocated with dogmatic conviction the idea that the rock formations shown there were universal in their extent and occurred everywhere in the same definite order. He did not believe that any rocks originated from the molten state. Volcanoes were to him nothing more than local and superficial outbreaks, the results of the burning of coal beds. The oldest and underlying rocks, showing a crystalline structure such as granite and gneiss, were classified as Primitive and asserted to be the precipitates from a primal universal ocean. Their crystalline nature was held to be a proof of this aqueous origin. Above the Primitive came the Transition series, followed by the Flœtz rocks, partly of chemical origin but in which mechanical sediments began to dominate. Coal, basalt, obsidian, porphyry, etc., were included in the Flœtz series as chemical deposits. Werner offered no reasonable explanation as to what became of the primeval universal ocean and he opposed all conclusions which rested upon the action of internal heat or deforming forces. He would not admit that mountains had been elevated or strata folded. From the disbelief of the Wernerians in the internal agencies of the earth and their assertion that all crystalline rocks had been precipitated from ocean waters they were named the Neptunists.

One of Werner's pupils, Robert Jameson, became professor

of natural philosophy in Edinburgh, the very home of Hutton and Playfair, whose work Jameson treated with contempt. For several decades, up to the time of Werner's death in 1817, his system of geognosy was dominant. A bitter warfare was waged between Plutonists and Neptunists, characterized on the part of the latter by provincial ignorance, dogmatic assertion, arrogance in place of demonstration. But the accumulation of incontestible facts undermined the morale of the system, showed that it was false from the foundation upward, and within a few years after Werner's death the whole had collapsed like a house of cards. Von Zittel in his excellent and impartial "Geschichte der Geologie und Paläontologie" states that the erroneous views held by Werner appreciably retarded the progress of geology, and in Germany after the collapse of his system the science of the earth seemed for a time to make no progress.[3]

Werner's real contribution lay in his orderly classification of minerals and rocks. Hutton's contribution on the other hand was nothing less than the establishment of the broad science of geology on a secure foundation.

The wide proclamation of Werner's system contrasted to the lack of advertisement of Hutton's is perhaps significant of the difference in national characters and is seen to show a certain parallelism to the developments of science and to the German propaganda a century later. The diverse racial stocks which made up the German empire, notwithstanding their belief in racial unity and superiority, have resulted in a wide range of temperament and ability, but Werner the Prussian is typical of the dominant national tendency to classify, to systematize, to consider this as the field of science, and with arrogant dogmatism to either discount or appropriate fundamental ideas originating elsewhere. A similar spirit has been sporadically manifested by individuals of other lands, but never with that frequency which would permit its development into a dominating national characteristic.

Near the close of the eighteenth century and opening of the nineteenth an era of scientific exploration set in. Three Germans—Pallas, von Humboldt and von Buch—were most noteworthy, Pallas being employed by the Empress Catharine of Russia, von Humboldt and von Buch being men of independent means. The energy and ability of these men contributed very much to a knowledge of the world, but to geological theory they themselves added comparatively little. The real growth of geology in the first third of the nineteenth century was largely in Great Britain and France. The advance is represented by the

[3] Pp. 48, 427, English translation.

appearance of manuals in French, German and English, culminating in the English works of De la Beche and Lyell, books which may be studied with profit even at the present day. The work of Cuvier and Brongniart had in France established paleontology during this same interval as a progressive branch of science.

With the opening of the second third of the nineteenth century the United States began to make notable contributions to geology. The initiation of state geologic surveys between 1830 and 1840 and of the Canadian surveys shortly afterward began an era of systematic and detailed scientific exploration in North America which in this regard led the world. In this same middle third of the century Darwin went on the voyage of the *Beagle,* and Dana as geologist and zoologist on the Wilkes exploring expedition. The geologic history of India, South Africa and Australia began to receive attention. In England Sedgwick and Murchison established the larger divisions of the Paleozoic era and in New York the detailed stratigraphy was worked out, with the result that locality names from England and New York dominate in the nomenclature of the Paleozoic.

In the field of theory Lyell established beyond controversy the principle which lies at the basis of all geologic science, that the past is to be interpreted by the study of causes now in operation. Elie de Beaumont in France, Dana and Hall in America, placed the theory of mountains upon a secure foundation. Bischof in Germany in his admirable text book of chemical and physical geology, published in 1846, made that country a leader in the division of geo-chemistry. From 1850 to 1858 the British geologist, Sorby, developed the methods for the microscopic examination of rocks. This through the German geologist Zirkel led to the great development of modern petrology which for the following twenty-five years, transplanted from England, became a distinctively German branch of science. Last, but not least, is to be mentioned the work of Charles Darwin which established the existence of organic evolution upon an unassailable basis.

In the last third of the nineteenth century appeared from Vienna the great work of Suess on "The Face of the Earth," welding into one treatise the geologic literature of the world and developing new views on the nature of continental and mountain-making movements. In Scotland the existence of great overthrust faults was demonstrated by British geologists, it being proved that ancient crystalline rocks had been shoved for more than ten miles over younger stratified formations. In France, before the end of the century, a new interpretation of

the Alps, of wide application over the earth, began to be conceived. Folding was seen to have passed into great overthrust sheets and erosion to have later cut these into remnants, leaving on the north side of the Alps mountains whose rocks had been deposited in previous ages far to the south, mountains without roots as they have been picturesquely called.

It was in America, however, that from 1867 to 1900 the greatest expansion of geology took place. After the close of the Civil War, under the auspices of the government, a group of young men of remarkable energy and ability began the scientific exploration of the western United States. The names of Powell, Dutton and Gilbert stand out above a worthy company and came to be known to geologists through both hemispheres. Their work laid the basis for the new science of physiography, developed so largely by Davis, which for the latest geologic epochs reveals the detailed history of the lands as the sequence of stratified rocks does for earlier ages. In the central part of the continent Chamberlin was establishing during this period the complexity of the Pleistocene, Irving and Van Hise were applying new methods and by them unraveling the structure of the ancient iron-bearing rocks of the Lake Superior region. In the field of paleontology Cope and Marsh explored the Tertiary and younger Mesozoic rocks of the west and brought forth from their stony tombs a legion of extinct vertebrates whose march across the stage of time made visible beyond question the story of their evolution.

Measured by the activity of its workers, by the immensity of its field, by the contribution to new ideas, it appears that by the year 1890 North America had taken a place of world leadership in geologic science. In the twentieth century, through many able workers in Canada and the Lake Superior region, our knowledge of the earlier geologic ages previously grouped under the name Archean has become expended into a complex history comparable in number of events and in duration to all subsequent time. A corresponding history has been worked out for their portion of the world by Scandinavian geologists.

With the increased knowledge of terrestrial processes as exhibited in continental interiors it has been shown by British, German and American geologists that the character of the topography influences the nature of the sediments, important formations are laid down in river basins and in deltas as terrestrial deposits. The first recognition of this importance of terrestrial deposition is to be credited to the British geologists in India. Wind has been shown by von Richthofen, Pumpelly, Walther and Passarge to play an important part in transporta-

tion, but some time before Darwin made note of the enormous quantities of dust swept into the Atlantic from the Sahara. The winds on the Indus delta were shown half a century ago to be as important as the river currents. Desert dunes are the waves of a migrating sea of sand. Eolian transportation and deposition is now given a large place in geologic theory. Climate is seen to be a major factor in controlling the character of even fluviatile and marine sediments, determining their structure and their content of iron and carbon. This more precise knowledge of the present has made possible a revision in that interpretation of the past which is derived from the study of the stratified rocks. Frequent breaks in sedimentation have been shown, chiefly by American geologists, to occur throughout the stratigraphic series, the larger of these, representing oscillations from sea to land and back to sea again, give rise in the strata to unconformities and disconformities. All of this new knowledge, most largely of American origin, is giving a clearer view of the oscillations of land and sea, of humidity and aridity, of heat and cold, and is establishing, as previously noted, two new divisions of historical geology—paleogeography and paleoclimatology.

The application of geology to the service of man, the field of economic geology, has undergone also a great expansion during the past generation, chiefly in America. Recognition of the usefulness of geology must result in advantage to the entire subject. It tends to draw more men into its ranks, it brings to the work a greater political respect, and from the ranks of the younger geologists who are able to win a living in useful geology will develop those capable of advancing the theoretical aspects of the subject.

Having given this survey of the past progress of geology, let attention be turned toward its probable future. The center of the greatest advancement during the next generation should be in North America. The preliminary survey of this continent has already been made. To men of limited vision it may have seemed that nothing of a large nature remained to be done. As a college student once said—he did not care to go into geology because since Dana had written his manual nothing remained to do except to fill in the details. Those engaged in research on the larger problems, however, are thankful that the continent has been studied and mapped to the present degree, since this preliminary work paves the way for an ever-expanding field of higher research. Such investigation must go hand in hand also with a more detailed and critical mapping which in

the United States alone bids fair to engage the energies of geologists for a century to come.

Another large field for the employment of geologists is as teachers in the universities. In the larger institutions of learning geology is recognized as of high cultural value, comparable to biology, serving to expand the mind of the student as do few other subjects. The history and nature of the earth and its inhabitants is an appropriate background for the understanding of the history and nature of man.

But although the preliminary geological survey of North America has been made, a considerable part of the land surface of the world is as yet imperfectly known. South America, especially, is a continent regarding which there is much to learn. Geological instruction in our graduate schools should be elastic and comprehensive enough to serve as training for men to work in other lands. Modern languages must be insisted upon as prerequisites for the higher degrees, not only as means of gaining access to the literature of other nations, especially France, Germany and Italy; but also as a means of facilitating research beyond the bounds of the English-speaking world, in such lands as South America, Siberia and China. The limitations of time forbid the requirement of more than two modern languages, but some knowledge of three or four would for those of natural linguistic abilities be of distinct advantage.

Another region which is as yet almost a *terra incognita* but which is open to future research is the great interior of the earth. A beginning has been made through geodesy, seismology, the geophysical laboratory, the nature of igneous rocks, and the forces which express themselves in deformation of the crust, but there is as yet much difference of opinion as to even the major conclusions. No secure knowledge can be had, however, as to the larger problems of the earth, such as its mode of origin, the source of igneous rocks, the causes of continents and ocean basins, until more is known with certainty and in detail of the earth's interior. This perhaps is the most difficult field of geologic science, requiring organized attack through the funds of institutions for scientific research, but it is a field whose tillage will yield rich returns.

This survey of the present standing of geology has been necessarily brief. Important subdivisions and fields of research have been wholly omitted, but the purpose of the article has been accomplished if it has shown in true perspective the contributions of different nations to the growth of geology, the branching out which has taken place from the parent trunk, and the resultant wide scope for future research in the science of the earth.

THE PRINCIPLES AND PROBLEMS OF GOVERNMENT

By P. G. NUTTING

IN living up to its possibilities, the chief ends to be secured by a sovereign state through the national government are national stability, strength and progress. Its chief problems relate to ways and means of securing these objectives. Some of these problems have been fairly well solved, others cry aloud for solution. Let us examine them from the standpoint of the engineer—applying fundamental principles to the general problem and to the more vital individual problems.

1. *National Stability.*—National stability requires that national authority be absolutely supreme over that of any individual or organization—political, commercial, religious or protective, within its jurisdiction. Each such organization or individual must regard the interests of the nation above its own. No mere confederation of states can possess stability unless individual states recognize the supreme authority of the nation. No nation can be stable if a strong commercial organization, such as a food trust, is so powerful as to be able to defy its authority. The same is true of a labor organization. Some few religious organizations have not always subordinated their interests to the interests of the nation, or else have wrongly identified their own interests with those of the nation. Many political organizations have placed party interests above those of the public at large. All such conditions constitute a menace to the stability of the nation as a whole.

While a nation can not be inherently stable without supreme authority, it can not attain the maximum of stability without denying every special privilege to every class, individual or organization. Not only must every organization, class or individual recognize the supreme rights of the nation, but equality of rights with its fellows. Any preferential treatment anywhere must lead to instability. From time to time aggregations of wealth have claimed special privileges, causing threats of upheaval. At present, the greatest menace to the nation appears to be in certain labor organizations which claim special privileges by encouraging and defending such crimes as murder, theft and the destruction of property when committed by

their own members against outsiders. The very attitude of one law for us, another for the outsider, can not be tolerated. The abolition of special privileges means equal rights and privileges to all and the enforcement of law without regard to wealth, class, race or organization. While equality of rights, in this sense, was expressly recognized and guaranteed in our constitution, it has never been completely established. Its establishment to the very letter offers many serious problems, but is essential in securing stability. In their attitude toward authority, efficient democracy and autocracy are alike, but in relation to special privilege they stand at opposite extremes as they do also in regard to the source of authority.

Every nation has its own peculiar problems in special privileges to solve, for in no nation have these been entirely eliminated. In some cases it is inherited class privilege, in others race and in still others organized labor—all more or less interwoven with special privilege exercised by wealth or political machines. Church domination has been a burning issue in the past and still is an issue in some nations. Both labor organizations and capitalists quite generally claim special privileges and each class is desperately striving to reduce and circumscribe those of the other class. American, British and Russian labor organizations fail to understand each other or to act together since the issues before each are essentially different. Each would be a tower of strength to its national government if each aimed and strove merely for the entire abolition of privilege.

While the complete abolition of special privilege is clearly a necessary and sufficient condition for national stability as a principle, yet the application of that principle in separate cases is not so obvious. Individual equality of rights before the law is one of the simplest and earliest recognized. Whether to workman or millionaire, master or servant, Jew or Gentile, black, yellow or white, party henchman or opponent, the law must be administered without personal or class favor. The principle is nearly as old as the human race, but even to-day, in America, the police and the lower courts are not entirely beyond the reach of personal influence. Equality of rights between corporations and between individuals and organizations has not yet been so clearly defined as between individuals, yet the same principle applies.

A very difficult problem of the near future in practically all nations concerns the abolition of special privilege in *property rights*. Labor is everywhere disputing with capital the assumed right and privilege of the latter to the sole disposition

of profits. Strikes, walkouts and widespread socialism are evidence that no rational, acceptable general solution of the problem has been reached. Labor desires remuneration without responsibility, hence requests a higher wage and shorter hours. Capital has generally accepted responsibility for profits, but in most large corporations is amply safeguarded against loss. But profits depend primarily upon good management and where such management is vested in salaried experts, these are entitled to such consideration as is accorded labor and capital. Equity in this case evidently demands that profits go to those who must shoulder responsibility for losses, but since that responsibility is variously apportioned in different organizations, no general solution of the problem appears possible.

The special privilege of one class to live in idleness at the expense of another class—an inheritance from feudal times—is still assumed in many countries and is the basis of widespread unrest. Such a privilege has not even a biological foundation since statistics show that leaders are born practically equally in all classes. A partial solution of the problem involves the abolition of hereditary titles, a high tax on incomes not under the expert direction of the owner and a very high or confiscatory inheritance tax on inheritances not going to dependent heirs.

2. *National Strength.*—While national stability comes largely from the elimination of misdirected static forces, national power is due largely to bulk of resources and to efficient administration. The resources that are effective include not only natural resources such as mineral and agricultural, timber and fisheries, but financial and intellectual resources and labor. The strength that lies in each may be great or little according to its conservation, development and utilization. These of course depend largely upon wise administration, direct in some cases, and through commercial and industrial organizations in others. It is the essential function of administration, in securing the general welfare, to see that the most possible is made of resources of all kinds. Comprehensive surveys determine resources while other departments regulate utilization, economic readjustments being made from time to time when necessary. Any one of the classes of resources above mentioned may range in value from absolute waste up to at least many times its worth at the present time, according to how it is handled.

The vital factor in making the most of our resources is of course expert direction. A poorly managed industrial organi-

zation will rapidly decline, but a poorly governed country may persist through its sovereignty. However, if a country is to live up to its possibilities, it must adopt the methods of successful industrial plants and have every important department managed by an expert. Administration consists essentially in solving an endless series of special problems. It calls for the services of engineers of all kinds, men who are at once thoroughly versed in the fundamental principles of their respective lines and experienced in the practical application of those principles. Some of these applications involve only routine repetition of previous applications. Others require study and investigation to determine which principles are applicable. Still others involve the most difficult research by master minds into the very fundamentals of the subject to uncover new principles. Hence the labor of administration ranges in quality from mere clerical and statistical work to fundamental scientific research in biology, psychology, geology, chemistry and physics. The experts required must be for the most part developed within the service itself after receiving a thorough preparatory training in the best appropriate educational institutions. Obviously, selection for the higher positions should be on the basis of fitness alone.

Both strength and stability require the coupling of authority and responsibility in proportion. The fatal defect in the so-called representative system of government is that while it may delegate authority it does not fix responsibility. Our office holders are not in office as a life work, with success or failure in life depending upon the wisdom of every decision. They have little to lose by mistakes and little to gain by a wise and faithful performance of their duties since they are quite likely to be superseded at any election. It is obviously the wise course to put the best experts available in every position of authority, place entire responsibility for their work upon them and leave them there until called to a higher position or until replaced by one more fit. It is doubtless possible to secure all the advantages of an autocratic government together with those of an efficient democracy by the wise selection and promotion of experts in administration. Democracy requires only that the *ultimate* authority rest directly with the people. A government with experts in authority, each assuming full responsibility for his work and subject to the ultimate authority of the people, represents the highest ideal of a republic.

Before proceeding to the discussion of factors in national progress, it may be well to consider a few of the greater na-

tional problems involving stability and strength, assuming that special privileges have been abolished, that the best available experts are in authority and that each is saddled with a responsibility that will bring forth his best efforts. One of the greatest of these problems concerns the relation of the government to national means of communication, information and transportation. The objective in each case is of course the maximum of public service at a reasonable expense. Efficiency depends in each case upon good management and wise expenditure. The matter of ownership has little to do with either. If better results have been attained under private ownership, it is to be attributed rather to better administration by better executives secured by means of higher salaries and better systems of selection and promotion. On the other hand, government administration has secured better coordination of effort. The interests of the public doubtless demand national control and control of a more intimate nature than the occasional exercise of ultimate authority.

Another great national problem relates to the best means of exercising ultimate authority by the people. In this problem are involved radical modifications of our present law-making and executive systems. Useful and effective laws could doubtless better be drafted by small bodies of well informed, experienced specialists in law drafting, men capable of correctly analyzing conditions to be remedied and of devising and framing laws for their alleviation than by unwieldy bodies of inexperienced delegates. For purposes of ratification, it is possible that Congress and the various state legislatures would serve better than frequent general elections in carrying out the will of the people. With administrative offices filled by appointment, partisan politics would largely disappear. The natural political parties are the conservative and the progressive and these are sufficient for all practical purposes in determining whether or not to take any new step contemplated. In our individual policies, the question constantly arising is whether or not to undertake some suggested line of activity and we are progressive or conservative according to the resultant of the political forces influencing us. The origin of each suggestion is of very little moment.

Representative government, as at present constituted, is but a weak and inefficient makeshift at best. It secures ultimate authority for the people, but in avoiding the evils of class autocracy has left us at the mercy of political bosses and machines. We have clean elections as a rule, but no means of

securing the best men available for the positions to be filled. Although open to objection, it would seem far preferable to have executives selected by some higher executive or board by promotion according to demonstrated ability than to childishly leave that selection to self-seeking politicians having no delegated authority and entirely without responsibility to the state. If it will but purge itself of special privilege—whether of birth, wealth or political organization—democracy is sure to exhibit administrative strength far in excess of that of the best devised imperialism.

3. *National Progress.*—The administration of the affairs of a nation should not only secure a maximum of stability and strength, but should direct the utilization of resources toward the greatest advance along all lines worth while. Obviously, if we are to make the most of our resources, those resources should be surveyed and studied with a view to their development for the greatest ultimate good of the nation as a whole. If we are neglectful of means of progress, we are sure to be outdistanced in time by nations which are progressive.

Our great administrative departments and bureaus have been created in recognition of just these national requirements. While leaving something to be desired in coordination and efficiency, in the main they fit our needs and render excellent service. A few, such as the Census Bureau, the Geological Survey and the Coast Survey, are engaged mainly in *gathering information*. The majority are concerned chiefly with the conservation and *development of resources*. Others look after *general welfare* through safeguarding public health, providing communication, national defense and transportation and regulating immigration, commerce, labor, banking, industrial organization and finance.

It is patent to every one that this work calls for the services of specialists and that greater results will be more efficiently obtained the greater the technical knowledge, skill and application of those specialists and the less the interference with their work by laymen. The nature of the work ranges from the purely administrative and clerical to scientific work of the most advanced and difficult nature. A considerable part of it has to do with the application of fundamental scientific principles to difficult technical problems and this involves a vast amount of research work. The government machinery should be such that the services of the greatest specialists in the country could be obtained and retained to carry on this work.

As it is, quite a number of the departmental bureaus are

headed by civilians chosen for their fitness alone and retained for their competency. These are doing excellent service. Others are headed by political appointees or staffed by henchmen and are examples of what should never be tolerated. Some have clear-cut fields of activity while others are sadly in need of reorganization and of coordination with bureaus engaged in similar lines of work. Some lines of government work urgently needed have never been undertaken at all. Some bureaus engaged in technical work lose annually to the industries from twenty to fifty per cent. of their staffs—as large a percentage as a university. To meet this condition it would seem advisable to organize such departments as a sort of great national university to draw greater numbers of choice research students, providing more timber from which to make up losses and from which to choose specialists for the higher positions.

A serious defect in many bureaus, resulting in far less than the best possible service to the public, comes from lack of direct contact with the public needs. Many industries, for example, would call on the government for expert advice and assistance but for the fact that it is not obtainable. On the other hand, the government has not made provision to meet such demands, chiefly because they were not made. It is precisely the dilemma of the repairs to the leaky roof. The government should provide for actual rather than expressed needs by building up strong, consistent, well-coordinated departments.

A number of important fields of general welfare, nearly or quite neglected by the government, might well be under its supervision and control. Conspicuous among these is education —mental, physical and moral. Common school education, now left to the several states, is in fairly good shape but higher education has been left to a large number of independent colleges and universities with but little even of unity of plan or purpose and to a considerable extent competitive. It is the obvious duty of the government to assume the leadership in this matter, retaining in its services the greatest specialists in the country, setting standards and conducting researches in methods of instruction and management. The practical education of the public through newspapers, magazines, lectures and motion pictures is left entirely to the private enterprise of money seekers. Physical education is left almost entirely to the instincts of the individual. Moral education is left to parental instruction, widely varying in quality and quantity, and to various religious organizations more or less at war with each other.

With the national welfare as its avowed objective and with

ways and means fairly obvious to those responsible for securing it, the really difficult problem is the judicious limitation of governmental activities to avoid stultifying paternalism in the regulative functions and interference with private interests in assisting the industries. In the past we have undoubtedly erred in doing too little, partly from principle but mostly through lack of expert knowledge. But with the pioneer period past and marked general tendencies developed in accord with conditions as they exist and are likely to persist, the time has come for a firmer grasp of our national destiny. We must do more than merely safeguard constitutional rights and trust to individual initiative. We must exert ourselves to the utmost to secure our national strength, stability and progress. In dealing with immigration, public health and education, for example, we must not be too tender of individual rights and privileges. In its relation to the agricultural, mining and manufacturing industries, the rôle of the government is not only that of the leading authority but of technical adviser, stimulator and regulator as well. Industrial development will mainly follow the lines of commercial interest with little regard to either the general welfare or to the distant future.

Among the most difficult of national problems are those concerning the relation of the nation to organizations—industrial, financial, political, religious, labor and racial—within it. National stability requires that national authority be supreme over every internal organization, whether that organization be a state or group of states, a power trust or group of related interests, a religious or racial organization attempting divided allegiance or a protective association of individuals. National strength requires that all such organizations be devoted to the general welfare rather than to selfish class interests. National progress requires that their activities be carefully directed, either by their own officers or by the national government and freely regulated by the government whenever necessary.

To secure such results, very little efficient constructive legislation has been enacted. While laws regulating the activities of individuals are abundant and effective, the corresponding laws dealing with organizations are few and ineffective. The Sherman Law, dealing with industrial organizations, is a conspicuous example. This law aimed to protect the people from extortion by monopolies. Secret agreements have nullified all attempts to restore competition. Efficient production has been hampered and the public has not been protected against overcharges. Natural and useful combinations have been driven

to secretiveness and evasion. The nation should welcome the formation of strong effective commercial and manufacturing organizations, provided only the government keep a firm hand on the helm and secure for the public a reasonable proportion of the benefits derived from organization.

Another class of organizations are striving not so much for material advantage as to dominate the nation for the advantage of a particular race, religious sect or class. These are the most insidious and the most difficult to deal with. This nation was founded on the principles of complete civil, religious and political freedom, tolerance and equality. That very freedom has been taken advantage of by those protected by it in an attempt to pervert those principles by securing a strangle hold upon the throat of the nation. We have nursed a brood of reptiles and the sooner we rid ourselves of them the less difficult will it be. No simple regulative Sherman Law is indicated in this case, but a searching test of loyalty with drastic penalties attached.

The various means of securing a maximum of national stability, strength and progress are utilized when individual ability is developed and utilized to the utmost. Perhaps our greatest weakness is too great a tolerance of incompetence in high places. Efficiency demands that not only competent but the *most* competent men available fill all positions of importance. In a pure autocracy no attempt is made to select the fittest for high places. In a pure democracy every place is in theory open to every one, but in practise the higher positions are clogged with incompetents and there are only occasional opportunities for clearing them out of the way. The principle is clear, but the best means of putting it in effect is one of the larger problems of the future.

A BOTANICAL TRIP TO MEXICO. II

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THE COMMON WILD GRASSES OF MEXICO

THE general botany of the country is not here elaborated, but the ecologist will readily coordinate the flora upon the basis of the grasses.

Eastern Coastal Plain.—The grasses of this region are illustrated by the specimens collected at Tampico and Veracruz. At the former locality the grass flora is poor in species and individuals. Only about twenty species were found, and many of them represented by single or scattering specimens. Along the brackish mudflats were found certain common marsh grasses, such as *Monanthochloe littoralis*, a creeping wiry grass with clusters of awl-shaped leaves about a quarter of an inch long; *Sporobolus virginicus*, with stout creeping rootstocks that send up short stems bearing conspicuously two-ranked leaves and a close cylindric flower head; *Paspalum vaginatum*, with numerous leafy stolons, the upright flower stems bearing a pair of slender flower spikes; and *Spartina spartinae*, a conspicuous marsh grass, growing in large tussocks, the leaves long, slender and sharp-pointed, the narrow flower cluster raised above the numerous leaves. On the sand dunes and sand flats along the beach one finds, besides the ubiquitous sand-bur (*Cenchrus carolinianus*) and crab-grass (*Syntherisma sanguinalis*), a species of *Eragrostis* (*E. secundiflora*) with erect stem about a foot high and a close, somewhat interrupted inflorescence. This grass is common in sandy soil as far north as Kansas. In pools among the dunes is found *Panicum geminatum*, a perennial water grass with smooth stems, creeping rootstocks and a narrow flower head several inches long.

At Veracruz there is a series of sand dunes separated from the sea by a wide sandy flat. Upon this flat are found several species of grasses in great abundance. Among these may be mentioned *Trachypogon Gouini*, an upright plant about two feet high with a conspicuous feathery flower head; *Sporobolus indicus*, a bunch-grass with long filiform leaves and very small flowers in a long narrow panicle; *Eragrostis Elliottii*, in

Tropical Jungle near Jalapa.

spreading clumps with a diffuse stiff panicle of long spikelets, a species of the southeastern United States; *Bouteloua filiformis*, a common species on the plateau. At the foot of the sand dunes there was an abundance of *Panicum Gouini*, a creeping plant with short upright stems, bearing an oval cluster of flowers. Among the other interesting grasses found at Veracruz may be mentioned *Eragrostis prolifera*, an unusually large species of the genus, with stout erect stems as much as seven feet high and a long loose panicle a foot or more in length. This species was evidently relished by stock, as it was found only when protected by the clumps of bull's-horn acacia or other thorny shrubs. Along the wagon road through the moist lowland there is a rank growth of Pará-grass. This grass is abundant in moist open protected places in the lowlands of tropical America, but does not appear to be a native of Mexico. It is introduced probably from Brazil. Veracruz is an interesting locality to the botanist because it was here that a French physician, Dr. Gouin, made a valuable collection of plants during the French occupation of Mexico. Several species are named for Dr. Gouin and the specimens collected by him at Veracruz are the types. Among these are the two species mentioned above, *Trachypogon Gouini* and *Panicum Gouini*.

Western Coastal Plain.—Collections were made at Manzanillo and Guaymas but the plants of the latter place are es-

A MODERN RAILWAY CROSSING THE ANCIENT HIGHWAY FROM VERACRUZ TO MEXICO CITY. This road is said to have been built by Cortez.

sentially the same as those of the Sonoran plateau and will be discussed under that head. The country around Manzanillo is hilly and the grass flora is meager, as the hills are covered with forest. On the cliffs and shore facing the ocean were found several kinds of grasses among which may be mentioned three. The rare *Bouteloua repens* was first described in 1816, under the name *Dinebra repens*, from the collections of Humboldt and Bonpland in the latter part of the eighteenth century on the seashore at Acapulco, Mexico. The species had remained unknown since that time, botanists having concluded that the original collection was probably a peculiar form of the common allied species *B. filiformis* (*B. bromoides* of many authors). The specimens collected by myself at Manzanillo, in the sand near the ocean, in the same habitat as those collected by Humboldt and Bonpland at Acapulco only a short distance to the south, correspond perfectly to the original description and plate of *Dinebra repens* upon which *Bouteloua repens* was founded. The second species is *Panicum molle* Swartz, found along the face of the cliff near the sea. This name has been misapplied to the Pará-grass (*Panicum barbinode*), but an examination of the original specimen in the Swartz Herbarium at Stockholm shows that it is the same as the plant

A STACK OF WHEAT NEAR POPO PARK.

here mentioned. This species, found from Mexico to Colombia and Jamaica, is a bushy little annual with small panicles of velvety spikelets. The third species is *Tripsacum lanceolatum*, a tall perennial with broad leaves and terminal clusters of two or three spikes of flowers, the lower parts of which are pistillate and break up into one-seeded joints, and the upper parts staminate, falling away entire. Single spikes arise also from the axils of the leaves. This species is more characteristic of the barrancas and rocky slopes of middle altitudes.

Except the grasses growing on the sandy flats around Veracruz, which should produce fair forage when young, the species mentioned for the coastal plain are of no particular agricultural importance.

The Plateau.—As stated previously the plateau region includes a large portion of the total area of Mexico and the grasses are correspondingly numerous and diverse. As the rainfall increases southward the grass flora becomes more abundant in that direction.

The Sonoran area is well illustrated by the collections made in 1908 at Hermosillo, Llano and Guaymas in the state of Sonora. The grasses are so numerous that only a few of the more conspicuous sorts will be mentioned here. The genus

A NATIVE LAUNDRY. Clothes are commonly laundered in streams, being beaten upon stones and then spread to dry upon the grass or shrubs. In the cities there are often public laundries in substantially roofed open buildings provided with running water.

Bouteloua, or the grama grasses, is represented by several species: *B. curtipendula* (side-oat grama), a bunch grass with erect culms one to three feet high, the inflorescence consisting of several short spikes on one side of a slender axis; *B. Rothrockii*, a smaller grass with a few longer spikes, also usually turned to one side of the stem; and *B. aristidoides*, an annual, six to twelve inches high, with numerous small and delicate spikes. *Panicum hirticaule* is an annual species with hirsute sheaths and diffuse panicles of small spikelets. *Heteropogon contortus*, found especially on rocky hills, is distinguished by the single scaly spike with several sharp-pointed brown fruits, each with a long more or less bent and twisted awn or tail. *Andropogon saccharoides* is a tall perennial, with hairy nodes or joints, and an oblong inflorescence, white and feathery because of the numerous white hairs among the flowers. *Chloris virgata* is a common annual weed, with several digitate spikes of fuzzy flowers.

The great central plateau, extending from the United States to the state of Oaxaca, is preeminently a grass region. The mesas, valleys and the lower mountain slopes support a large number of species of grasses that are able to thrive under arid or semiarid conditions. The abundance of the growth depends

A TYPICAL SCENE IN RURAL MEXICO. The pointed straw hats with wide brims are universally worn by the peons. The hats with upturned brims often serve in lieu of pockets as receptacles for small parcels.

upon the amount and distribution of the rainfall. As stated in a previous paragraph the annual rainfall increases toward the south. The arid portion of the plateau extends south to approximately the twenty-second parallel, thus including the state of San Luis Potosí. The grasses of this region were studied at Miñaca and Chihuahua in the state of Chihuahua, Torreón and Saltillo in the state of Coahuila, Monterey in the state of Nuevo León, Durango, Zacatecas, Aguascalientes and San Luis Potosí. Attention will be drawn to only a few of the more common species found in this area. Two species of grama grass are common and are important forage grasses, *Bouteloua hirsuta* and *B. gracilis*, both perennial bunch grasses, the inflorescence consisting of two or three spikes at the top of the stems. One spike stands at the end and the other one or two a short distance below, all turning to one side and moved about by the wind like little vanes. Several species of *Aristida* are common, but of little value from a grazing standpoint. The fruit is sharp-pointed and bears three slender awns, whence the names triple-awned grass and spear-grass. The sharp fruits are troublesome to stock, often working into the flesh and causing irritation. The genus *Stipa* is well represented. The fruit is sharp-pointed but bears a single long awn. The buffalo grass (*Bulbilis dactyloides*) and curly mesquite (*Hilaria*

THE FAMOUS IRON MOUNTAIN AT DURANGO, made up mostly of iron ore.

cenchroides) are small sod-forming grasses, propagating by runners. The flowering stems rise to the height of only a few inches. *Sporobolus*, *Muhlenbergia* and *Epicampes* are well represented. Two species of the first genus, *S. Wrightii* and *S. airoides*, called sacaton, form large tough tussocks, the flowering stems bearing a diffuse panicle of small flowers. The first-mentioned species is taller, reaching the height of five to six feet. There are many small species of *Sporobolus* and *Muhlenbergia* that form a considerable portion of the grass flora, the latter genus differing in having awned florets. The species of *Epicampes* are tall coarse grasses with narrow, usually pale inflorescence. Three small grasses belonging to three genera, but resembling one another in general appearance, are common upon dry hills. They are *Muhlenbergia Wrightii*, *Pappophorum Wrightii* and *Lycurus phleoides*, all agreeing in having a spike-like inflorescence, but differing in the structure of the spikelets.

Over the southern half of the plateau the aspect of the grass flora is similar to that of the northern portion, but the species differ slightly. There are other species of *Bouteloua* and of the allied genera *Pentarrhaphis* and *Cathestecum*.

Collections were made at Zapotlán and Guadalajara in Jalisco, Irapuato and Acámbaro in Guanajuato, Querétaro, Pachuca in Hidalgo, Toluca and Popo Park in the state of Mexico, various places in the Federal District, Uruápan in Micho-

A CLUMP OF *Tripsacum lanceolatum* GROWING ON IRON MOUNTAIN, NEAR DURANGO.

acán, Cuernavaca in Morelos, Chalchicomula, San Marcos, Esperanza and Tehuacán in Puebla, and Oaxaca in the state of the same name. Upon the mesa in the state of Puebla certain species of *Stipa* are conspicuous because of the long narrow nearly white inflorescence. They are bunch grasses with narrow leaves (*Stipa Ichu, S. multinodis, S. tenuissima*). Over a considerable proportion of the table land the cactuses and yuccas are a conspicuous and often dominant element of the flora.

Slope from Plateau to Coastal Plain.—Except in the northern part of Mexico the slope from the table-land to the coastal plain is rather abrupt, and in some places, such as in the eastern part of the state of Puebla, extremely abrupt. This slope is marked by a series of foothills and deep ravines. These ravines, fixing the position of the water courses and often 2,000 or more feet deep with precipitous sides, are known by the Spanish word barrancas. This slope with its attendant magnificent scenery may be seen from the railroad in going from San Luis Potosí to Tampico, from Mexico City to Veracruz by way of Orizaba, and from Guadalajara to Manzanillo. In passing from Puebla to Oaxaca the railroad descends to less than 2,000 feet at Tomellin and then ascends through the beautiful Tomellin Canyon to the table-land. About six miles east of Guadalajara and easy of access is another remarkable can-

A SCENE ON THE MEZA OR PLATEAU IN NORTHERN MEXICO. An adobe house at the left. Adobe is made by mixing the clay soil with water and adding straw for binding. The plastic material is shaped into large bricks and dried in the sun. Adobe is much used in the northern states of Mexico where the rainfall is light. It is also used in southern Arizona and New Mexico.

yon, the Barranca de Oblatos, through which passes the Santiago River, the outlet of Lake Chapala. These slopes and barrancas are usually covered with grasses and other herbaceous vegetation. Forest is by no means absent, and the proportion increases toward the lower altitudes, but the tops of the hills and the steeper sides of the barrancas are usually too dry to support woody vegetation, and here the grasses abound. The number of species of grasses is greater in this region than in any of the other floral areas. The following are a few of the more conspicuous grasses observed along the rims and sides of the Barranca de Oblatos: *Heteropogon contortus*, a perennial with spikes of imbricated bracts from beneath which protrude stout brown awns several inches long, the hard sharp-pointed fruit from which the awns spring resembling those of the genus *Stipa; Heteropogon melanocarpus*, an annual with stout stems four to six feet high and awned fruits like those of the preceding; *Muhlenbergia elata*, a tall leafy bunch-grass, with long harsh narrow leaves and a large purple rather diffuse panicle over a foot long, with numerous small long-awned spikelets; *Arundinella Palmeri*, a grass resembling the preced-

THE OUTSKIRTS OF ZACATECAS. Much of the country here consists of rolling barren hills. The houses are mostly adobe. The projections near the upper part are pipes for conductingg away the water from the flat roofs.

ing in general appearance, but easily distinguished by the broad flat blades and the denser panicle of larger spikelets, each with a bent and twisted awn; *Tripsacum pilosum*, a tall cornlike grass, as much as twelve feet high, with broad blades and hispid sheaths, and a terminal tassel, the spikes of which are pistillate below and staminate above; *Tripsacum lanceolatum*, a smaller species than the preceding, usually not more than four or five feet high; *Andropogon perforatus*, conspicuous with its woolly-white terminal inflorescence of clustered spikes, each spikelet provided on the back with a small pit, like a pin hole; *Paspalum virgatum*, with broad flat blades and a terminal brown or purple inflorescence of numerous spikes, the spikelets circular, flat on one side, convex on the other, nearly sessile along one side of the axis.

Guadalajara was visited by the famous traveler Humboldt and is the type locality of many plants collected by his companion Bonpland.

At Alzada, a station on the railroad a few miles above Colima, at an altitude of about 1,500 feet, a number of interesting and conspicuous grasses were seen. *Tripsacum laxum*, a large tall cornlike plant, six to eight feet high, resembles

Pine forests at Sanchez in the Sierra Madre, Chihuahua.

Tripsacum pilosum mentioned in the preceding paragraph, but differs in having smooth sheaths. All three of the species of *Tripsacum* were found at Alzada and were usually observed growing upon rocky grassy hillsides. *Pennisetum setosum*, also growing upon cliffs and slopes, has slender culms three to five feet high, terminating in long red spikes, one half inch thick and six to eight inches long. *Lasiacis procerrima* is a tall reedlike grass as much as eight feet high, with numerous broad blades, the base heart-shaped and clasping the stem, the panicle large and spreading.

The eastern slope from the plateau was visited at Cárdenas and at three points in the western part of the state of Veracruz. Much of the region between Cárdenas and Las Canoas on the railroad between San Luis Potosí and Tampico is a rolling prairie, reminding one of the prairies of Iowa. Here were found curly mesquite (*Hilaria cenchroides*) and buffalo grass (*Bulbilis dactyloides*), both common in the plains of Texas, and *Paspalum notatum*, a common species in pasture land at middle and lower altitudes in Mexico and Central America, distinguished by its divergent pair of spikes two or three inches long, with two close rows of sessile spikelets flat on one side and convex on the other. *Bouteloua hirsuta* (black grama) and *B. filiformis*, as well as the widely distributed *B. curtipendula*

MT. ORIZABA NEAR THE TIMBER LINE. An alpine meadow in the foreground; a coniferous forest in the background.

(side-oats grama), were found on these prairies. *Panicum bulbosum*, a perennial species with spreading panicle, is recognized by the thickened bulb or cormlike base which suggested the specific name.

Western Veracruz is particularly interesting because this region was visited by well-known botanists many years ago and a large number of new species were described from their collections. Liebmann, a Danish botanist, made large collections here between 1840 and 1843, especially at Mirador, a hacienda on the east slope of the Mt. Orizaba crest and northeast of the peak. Sartorius, the owner of this hacienda, was also a botanist of note. Schiede and Deppe collected in this region in 1828. Galeotti spent six months at Jalapa, about 1835; Botteri collected around the city of Orizaba in 1850; Müller collected between Veracruz and Orizaba in 1853; Bourgeau, whose collections were probably larger than any of the others mentioned unless it be Liebmann, was sent to Mexico in 1865 by the French Scientific Commission and collected especially at Córdoba and Orizaba.

Jalapa, at an altitude of 4,600 feet, presents a mixture of open prairie and tropical jungle. On the side of a clay cut along the railroad were found several species of *Panicum* belonging to the subgenus *Dichanthelium*. These were of in-

A THATCHED HUT. The common style of dwelling in the country of southern Mexico.

terest botanically because this group of plants is represented by a large number of species in the eastern United States but by few species in Mexico and Central America. Here in this one locality were found six species of this subgenus (*P. xalapense*, *P. viscidellum*, *P. sphærocarpon*, *P. multirameum*, *P. Joorii*, and *P. olivaceum*). *Panicum xalapense* was first collected at Jalapa (or Xalapa as it is sometimes written, the letters j and x representing the same sound in Spanish) but is rare in Mexico, although a common species in southeastern United States. On the prairie were found several tall species of *Andropogon* and allied groups: *Andropogon virginicus* with clusters of delicate woolly spikes scattered along the stem; *A. condensatus*, with short spreading blades and a rather dense inflorescence of numerous spikes; *A. glomeratus*, stiffly upright with a white-topped dense club-shaped inflorescence of delicate woolly spikes; *Elionurus tripsacoides*, with a single terminal spike of rather woolly spikelets; and *Sorphastrum parviflorum* with a close golden-brown panicle of small spikelets. At the edge of the jungle was found *Chætochloa sulcata*, a very ornamental grass with broad plaited blades and a stiff narrow bristly panicle of purple spikelets.

Near Orizaba, just at the western edge of the city, rises a steep rocky hill, much of which is covered with grass. This

WOODED HILLS NEAR COLIMA. A thatched hut with a small patch of corn, surrounded by a fence of interwoven slender poles.

hill, because of its accessibility from the city, has undoubtedly been visited by all the botanists, and there have been many, who have sojourned at Orizaba. This hill is probably the type locality of many species of grasses and the writer is of the opinion that, in some cases at least, he procured specimens from the identical bunch or patch from which specimens had been obtained by these botanists and which became the type specimens of species described by them. *Epicampes Bourgæi*, a coarse rough-leaved bunch-grass with a stiff narrow panicle of pale spikelets was named for Bourgeau, one of these botanists. In the shade of trees at the base of a rocky cliff was found a rare species of *Panicum* (*P. Schmitzii*) described by Dr. E. Hackel from a specimen sent to him as coming from Mexico, but with no data as to locality, collector or date of collection. This grass has broad short flat blades, the shoots being strongly dorsi-ventral, as is the case with many tropical grasses growing in the shade, for example, species of *Oplismenus* and *Ichnanthus*. This rare grass was found again on a shady wet bank at Córdoba, and was collected also by Pringle at Las Canoas, which is also on the slope from the plateau. In the woods at the top of this hill was found a species of woody grass (*Lasiacis sorghoidea*). There are many species of this group in the tropics. They resemble bamboos

A RAILWAY NEAR TOLUCA. On each side are fields of corn, with a fringe of barley. The space between the rails and a little on each side is the highway for peons and burros.

in having woody stems and broad short blades. The flowers, however, show that the group is allied to the great genus *Panicum*, of which it has been considered a section, but from which it is distinguished by the woody culms and and the shape and texture of the fruit. One specimen of *L. sorghoidea* was found growing in an open area where it was free to assume a bushy form. The clump of culms, twenty to forty in number, rose to a height of ten or fifteen feet, the upper portion curving gracefully outward. The small branches were borne in whorled clusters at the nodes. When in flower the panicles terminate these branchlets. When growing among shrubs or trees, as is usually the case, the culms clamber upward through the supporting branches for as much as thirty feet. Another interesting member of this group (*L. rhizophora*) was found along the edge of the jungle at Córdoba. In this species the culms do not climb high, but form an intricate tangled mass of branching rooting stems that remain near the ground, the leafy shoots rising to the height of three or four feet.

High Mountains.—Many mountain ranges traverse the plateau. Those toward the western edge are collectively known as the Sierra Madre, and may be considered as a southward extension of the Rocky Mountain system. Several notable volcanic peaks arise as isolated cones, some of them into the region of perpetual snow. The writer ascended three of these

A STREET-SCENE IN THE OUTSKIRTS OF CUERNAVACA.

peaks, Orizaba, Popocatepetl (pronounced Po-pó-ca-tê-pet'-l) and Nevada peak of Colima, the two former rising above snow line, which is at about 15,000 feet in the late summer. The distinctly mountain flora becomes dominant at 10,000 to 11,000 feet. Above timber line (11,000 to 13,000 or even higher in protected places) the grass flora is alpine or at least subalpine. The first peak to be visited by the writer was Popocatepetl. From Popo Park as a base, taking a burro to carry the supplies and light camp outfit, and accompanied by my son as assistant, I ascended as far as the snow line. This trip was particularly interesting because we made our way on foot without a guide or a map, through a region entirely unknown to us. We soon lost the regular trail and meandered upward through the open forest and later on the vast sand and lava stretches above timber line. Upon these alpine plains and ridges the weather was capricious, but mostly foggy or stormy. There were violent squalls with rain, hail or snow, often accompanied by high and variable winds. The trip occupied three days, the two nights being spent at about 11,000 feet.

A conspicuous grass in the lower mountain belt (9,000 to 11,000 feet) is *Festuca amplissima*. This grows in large bunches or tussocks, the leaves numerous, the culms as much as six feet tall, and the lower branches of the large mature panicle reflexed. These bunches, scattered rather thickly

THE HOTEL AT MIÑACA, a junction point on the road from Chihuahua City to Sanchez. Typical of the buildings in northern Mexico, hot and dry on the outside, fairly cool and comfortable within.

through the open woods, give a dominant character to the vegetation. Another bunch-grass (*Cinna poæformis*), somewhat similar in appearance but in smaller light-green bunches about a foot in diameter, is found intermixed with the preceding. There are also, upon the mountain side in this belt, vast areas of open land upon which the dominant and sometimes almost exclusive plant is *Epicampes macroura*, the roots of which are used in the manufacture of scrubbing brushes. The plants grow in large tough tussocks one to three feet in diameter, in rich soil the tussocks touching one another, the leaves numerous, stiff and harsh, the inflorescence a long narrow stiffly upright spike. The bunches of *Epicampes* are evidently sought by cattle, as the ends of nearly all the leaves were eaten off. Growing within the protection of the *Epicampes* was a species of *Bromus* (*B. exaltatus*) with slender stems and a loose panicle resembling oats. In more exposed places this species was often prostrate. At higher altitudes other species became more prominent. A delicate species of *Festuca* (*F. willdenoviana*), one to two feet high, with soft short leaves and a nodding few-flowered panicle, was common in the upper wooded belt. Here were also *Poa annua*, the common weedy

A PRIMITIVE CONTRIVANCE FOR RAISING WATER FOR IRRIGATION. The horse turns a large horizontal wheel. The vertical pegs on the under side engage a similar series on the side of the vertical wheel, which in turning raises a line of buckets on the circumference. The supporting pillars are of adobe. Near Zacatecas.

Poa of our eastern states; *Poa conglomerata*, a usually prostrate plant with a narrow dense panicle, and *Graphephorum altijugum*, with delicate erect culms and a narrow panicle. Just above timber line in the bunch-grass belt were found *Festuca tolucensis* and *Calamagrostis tolucensis*, originally collected in similar situations on Mt. Toluca, a volcano near the city of Toluca. They both have numerous narrow erect leaves. The latter species extends to snow line and in favorable situations forms a sort of fairy-rings, due to the indefinite expansion of the tussock and the death and decay of the interior, leaving a narrow annular zone of the living grass. These rings may be many feet in diameter, but finally break up into segments and the original ring becomes indefinite or obsolete. Other grasses of this alpine region are *Agrostis Schiedeana*, *Trisetum spicatum*, common in the high mountains in the United States and extending to the Arctic regions, and *Festuca livida*, a low grass growing in the volcanic sand below snow line, conspicuous because of the comparatively large deep-purple spikelets.

Mt. Orizaba was ascended from Chalchicomula, on horseback with servants (mozos) and guides. Two days were taken

A LARGE ALFALFA FIELD NEAR TOLUCA. In this field of over one hundred acres the alfalfa was grown in rows and cultivated.

for the trip, the night being spent in a cave about timber line. The writer ascended the peak over the snow nearly to the top, but was prevented from reaching the actual summit by the violent gale blowing from the east. Many of the species mentioned above as occurring on Popocatepetl were also found on Orizaba (such as *Bromus exaltatus, Poa conglomerata, Trisetum spicatum, Festuca amplissima, F. livida, F. tolucensis, Epicampes macroura*). Another *Festuca* (*F. hephæstophila*) and a species of *Calamagrostis* were collected. The *Festuca* grows in small tufts, looking like our sheep's fescue. This and *Calamagrostis Schiedeana* grew together in the grassy meadows above timber line, the latter in large bunches like *Calamagrostis tolucensis*. Both have numerous firm involute root leaves, with a papery tawny base peculiar to alpine grasses.

Mt. Nevada was reached on horseback from Zapotlán over a good trail. Two days were taken for this trip, the night being passed in a cabin at about 11,000 feet. The dominant grasses in the upper regions of the timber and extending well above timber line are *Calamagrostis tolucensis* and *Festuca tolucensis*, both found on Orizaba. This is interesting as showing the similarity of the flora of the mountain tops as compared with the diversity in the flora of the lower regions. *Trisetum spicatum* was found throughout the region above timber up to the very summit.

A FIELD OF ALFALFA NEAR SAN LUIS POTOSÍ. The plants are cut by hand, piled in heaps, and then tied in bundles for transport.

The grasses of the northern Sierra Madre were studied at Sanchez, then the terminus of the railroad from Chihuahua to Topolobampo. This is on the continental divide at an altitude of about 8,000 feet, in the midst of pine forest. The species of grasses found here are in the main different from those found in the other regions mentioned, and the flora shows a close affinity with that of southern Arizona. The dominant grasses are species of *Muhlenbergia*, *Sporobolus* and *Epicampes*. Certain annual species were especially abundant, such as *Sporobolus ramulosus*, *S. confusus*, *S. Shepherdii* and *Muhlenbergia peruviana*.

Grasses of Ponds and Marshes.—The grasses of ponds, marshes, river banks and similar situations occupied by water plants are much the same throughout Mexico. The flora of fresh-water ponds is well illustrated by the grasses seen at Orozco, a station twelve miles south of Guadalajara. Certain species were found only in the water, such as: *Panicum paludivagum*, with a long narrow inflorescence of several short appressed spikes, and very long submerged rooting stems; *Panicum sucosum*, with spreading panicle and long submerged stems as in the preceding; *Paspalum longicuspe*, growing in deep water among water-lilies, only the inflorescence emerged, this consisting of numerous flat spreading spikes, the indefinitely long rooting stems submerged, but floating by means of

A FIELD OF PARÁ GRASS NEAR URUÁPAN. This is a common forage grass at low altitudes in Mexico. Mostly cut and fed green. A native of Brazil.

the large masses of roots at the nodes; *Echinochloa holciformis*, a tall erect broad-leaved grass, rising well above the water and bearing a close panicle of large long-awned spikelets; *Homalocenchrus hexandrus*, a small, rather delicate, but wiry grass, with a small panicle of very flat spikelets. Along the edge of the pond, growing in mud or in shallow water, were found *Distichlis spicata* (salt grass), *Paspalum vaginatum*, with a pair of spikes at the summit of the slender culm, *Echinochloa zelayensis*, allied to our barn-yard grass, and *Leptochloa fascicularis*, with several stiffly ascending spikes.

Distichlis spicata, mentioned above, is a common grass in moist alkaline soil and along the banks of ditches. Another common plant in such situations is *Paspalum distichum*, which resembles *P. vaginatum* in having two divergent spikes at the summit. Along the margins of ditches and streams where the soil is not especially alkaline one finds *Polypogon elongatus*, with slender lax stems and a narrow panicle of small flowers turning yellow with age; *Panicum laxum* and *P. pilosum*, small plants with several spikes of small round spikelets, and many species of *Paspalum* characterized by their plano-convex spikelets. *Arundo Donax* is a large reed with broad leaves, stems as much as twenty or thirty feet high, and large feathery

A COCONUT PALM AT URUÁPAN. It is rather unusual to find coconuts growing so far from the coast.

plumes when in flower. This reed, introduced from Europe, often grows in dense masses along the banks of irrigation ditches.

Weedy Grasses.—Many of the weedy grasses of cultivated soil and waste places are introduced from the Old World. Others are natives of Mexico or Central America. The following are the more common and widespread species.

The annuals will be mentioned first, as they are the common weeds of cultivated fields: *Syntherisma sanguinalis* (crabgrass), with spreading stems, hirsute sheaths and slender digitate spikes, common everywhere; *Eragrostis mexicana*, with a diffuse panicle of lead-colored spikelets, very common in cultivated soil, throughout Mexico; *Eragrostis caroliniana*, similar to the preceding but with smaller spikelets, less common; *Eragrostis ciliaris*, with a narrow panicle of strongly ciliate spikelets, a weed of streets in the coastal plain; *Panicum fasciculatum*, with panicles of round reticulate yellow or dark-brown

spikelets, the main branches spikelike, common in fields at lower altitudes; *Panicum hirticaule*, with a diffuse panicle, resembling our old witch grass, common at low and medium altitudes on the Pacific slope; *Brachiaria plantaginea*, with a few spreading spikes of roundish spikelets growing in moist cultivated soil; *Leptochloa filiformis*, with many slender spreading purple spikes of small spikelets, common in rich fields in the coastal plain; *Cenchrus carolinianus* and *C. echinatus* (sandbur), the former with a looser spike of burs, common in fields and waste places; *Eleusine indica* (goose grass), a smooth grass with a few digitate spikes, found chiefly along streets and in waste places. There are, of course, many other weedy annual grasses, but the above are the commoner kinds.

The perennials are fewer in the number of the species and are found chiefly in pastures and waste places. *Chætochloa geniculatus* (fox-tail) resembles our northern species, differing in being perennial, one of the few of this class common in cultivated soil. *Holcus halepensis* (Johnson grass) has obtained a foothold here and there, and may prove a serious pest, as is now the case in Texas and other of our Southern States. *Sporobolus Berteroanus* (smut grass) can be recognized by its long slender panicle of small flowers that are frequently blackened by a fungus. Certain species of *Paspalum* are common in meadows, pastures and along roads (*P. convexum*, *P. plicatulum*, *P. squamulatum*). *Paspalum conjugatum*, with stolons and a pair of long slender spikes, is very common in tropical America and extends into the lowlands of Mexico.

The grasses obtained on this trip yielded one new genus and twelve new species, and in the study of the collection ten more new species were found among the grasses secured by others.

THE ENGINEER'S PART IN AFTER-THE-WAR PROBLEMS

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THE engineer—as his designation implies—is the man of ingenuity, the man who has a vision of the future and who, without being visionary, can see and devise methods of producing results by utilizing the forces and resources of nature. His business is to plan and build. During the war his was the task of devising ways of protecting friends and destroying enemies. Now, with peace assured, his task is to make ready and get the machinery of construction and operation into full motion again. His part is also that of the pioneer to explore, to conduct researches into realms beyond our present knowledge and with facts thus secured plan out the safe way for others to follow.

In the countries where war has wrought its destruction, the duty of the engineer is primarily to rebuild, but with us, more fortunately situated, where the disturbance has only been relatively small, our part is to wisely provide for larger and better uses of our resources and prepare for the better communities toward which all of us aspire.

While the war has wrought little destruction to us in Illinois, and in fact has, if anything, increased material prosperity, it has "laid its fearfully vitalizing hand upon our people," and has served to greatly widen their viewpoint. It has made possible the realization of some of those ideals which a few years ago were regarded as impracticable. In other words, the established order has been so far disturbed as to render it wise to urge improvements which before the war seemed to be out of our reach. This has been stated by Winston Churchill, "If for five years after the war the people devoted the same energy, cooperation and self-sacrifice to reconstruction as have been devoted to the process of destruction, there is no social, industrial or economic problem which could not be conquered."

The question confronts us therefore as to how in this present crisis of world affairs the engineer and organizations of engineers, both individually and collectively, can perform their largest service. What are the steps to be taken in order that we may do our full duty as citizens?

It is desirable to emphasize the fact that engineers as a class owe a larger duty to the public than almost any other group. They have been educated largely at public expense and given the opportunity of enjoying a wider outlook upon the forces and activities of nature than have most of our fellows. Because of this fact there rests upon them the obligation to utilize these advantages in the most efficient manner for the general good. They have already shown what they can do under the stimulus of war. Now under peace conditions—which should be even more inspiring—it is for them to demonstrate their continued value to humanity. The question is as to how this can best be performed.

1. *Diffusion of Information.*—Under our form of government any notable advance or improvement must be made largely through the support of the majority of the thinking people. To secure wise action it is obviously necessary that the public be well informed as to the objects to be attained and relative costs and benefits involved. The engineers in short should do everything in their power to diffuse information regarding the matters in which they are skilled in order that the public may be able to act intelligently.

In the past, it must be acknowledged, engineers as a body, particularly as represented by our larger societies, have been remiss in taking the public into their confidence regarding the facts and conclusions to be drawn regarding many important engineering matters. In fact, we have rather prided ourselves upon this condition and upon our close adherence to narrow technical detail. As a consequence not only the public has suffered but the engineering profession even more so in being regarded as technicians; the engineer has been classed in the same group with the engine runner or fireman but without enjoying anything like the influence on public affairs had by the latter.

Our first and foremost part in the after-the-war or reconstruction problems is obviously that of aiding the public through the diffusion of information as to the nature of these problems and their solution since most of them rest upon matters which come mainly within the cognizance of the engineer.

2. *Research.*—Closely connected with the duty of diffusing information is that of encouraging in every practicable way the acquisition of additional information regarding natural resources of the country and the methods of utilizing these. While much is already known there lie in every direction innumerable unanswered or partly answered questions to which

it is necessary to obtain complete and satisfactory replies in order that progress may be made. Here engineers individually and collectively have a duty, namely, that of stimulating continued study and research into those conditions which are often assumed by the public to be facts and yet concerning which comparatively little definite information can be had. Most of these present-day problems relate to transportation and its control, to the movement of persons and goods, to better methods of road construction and maintenance, the restoration of navigation, better water supply for towns and industrial establishment. There are innumerable lines in which the engineers and their organizations should be actively at work either directly or in stimulating others.

3. *Preparation of Plans.*—In connection with the diffusion of information and stimulation of research it is incumbent upon the engineers to use the experience and ingenuity with which they are endowed to make general plans and bring before the public the possibilities of larger health, comfort and prosperity. It is true that the details can only be worked out with safety after adequate funds have been provided, but it is nevertheless possible to outline the picture in a broad way and to keep continually before the people or communities concerned a conception as to what may be done by the use of information possessed by the engineer or which may be had by further study. In reply it may be urged that the busy engineer immersed in the details of his daily work has little time for such matters. Nevertheless, reflection will show that even the busiest must have a certain relaxation and that he will be improved mentally and morally, and possibly gain in a financial way if occasionally he lifts his eyes from his desk and permits his mental vision to take in the larger aspects of the things with which he is familiar. Moreover, the contact with his fellow men in the direction of their vision to the wide scope of engineering possibilities must have a beneficial effect in counteracting the narrowing influences of professional detail.

Reconstruction Problems.—But what are these after-the-war or reconstruction problems? How do they differ from the ordinary routine? In many ways these do not differ but are the culmination and grouping together of many questions which have been before us for a generation but which are now demanding early attention. They take in the whole range of human activity, but may be classified for convenience into three groups in the order of their immediate insistence.

(*a*) Men or man power.
(*b*) Materials or natural resources.
(*c*) Ideals or plans.

(*a*) *Men.*—The immediate and vital question following the war is that of demobilization of the army, providing employment for returning soldiers and war workers and the reconstruction of the crippled or injured men. The latter is being given attention by the War Department and theoretically at least no man is discharged from the army until he is equipped as far as humanly possible to make a living at some suitable occupation.

This reconstruction of men is the first and most pressing duty, one in which the time element is vital. It began with first aid to the wounded and was continued not merely through hospital service but through reeducation activities or vocational training such that the man injured in the service of his country is restored as completely as possible to health and rendered self-supporting through the use of artificial limbs supplied to him. He is aided by the acquisition of a training in vocational or even in engineering occupations which enables him to become a self-supporting and self-respecting citizen after he has done his part in winning the war.

More than this the reconstruction plans involving the return to industry, in the quickest and best way, of the munitions workers and others who have been employed more or less directly in connection with the war and to do this in such a way as not to interfere with the earnings or proper enjoyment of others who have taken their former places in industry.

The present problem is that of finding work immediately for these men and women who are returning to the industries which have been discontinued or which have not yet come into active operation. Here is demanded not charity nor political discussion but immediate practical action. This can come about in many ways.

1. By urging that each and every employer take on as many people as he can and in spite of present high prices incur every reasonable business risk in getting his operations under way.

2. In urging public officers and persons having control of expenditures of public or private organizations to undertake at once the works which have been planned or contemplated such as highways, waterways, water supply, drainage systems, public buildings, parks and all those things which benefit the public. In opposition it is urged that there is scarcity of material

and prices are high. Even though this be true, it is often possible to substitute materials; even though the prices may be high it is a matter of public economy in the long run that the work be performed now and that an outlet be afforded for labor on things which are ultimately of use.

(*b*) *Materials.*—In the reconstruction problems having to do with materials there is a far wider diversion of interests and of methods; the first and most vitally important are those things which have to do with food production and transportation. Next in importance are the fuel problems and then the other natural resources such as raw materials needed in manufacturing. Fortunately, the study of these resources, their distribution and best employment in industry has been the subject of investigation by a group of conservationists and engineers who during the past decade aroused interest in these matters. Due to their systematic efforts there has been made by various federal bureaus a beginning upon the systematic collection of data.

Each and every business man and agency needs to be stimulated to larger efforts and to a consideration of the practicability of putting to full use all of his resources whether of raw materials, agricultural products, manufactured articles, or of human or man power. To do this effectively there must be an agreement upon the larger ideals or underlying principles which result in well-considered plans of action.

(*c*) *Ideals of Reconstruction.*—No far-reaching result can come about from the planning of the use of man power or of raw materials until there has been a general agreement upon fundamental principles. It is true that the working out of these to a form where they will be generally agreed upon may not be accomplished for some months. In the meantime certain details involving employment of men and use of materials may be satisfactorily entered upon. There should be an immediate discussion of ideals even though agreement on the statements of them may not be reached for some time.

On most of the fundamental ideals there will probably be sharp division between two great parties, representing opposing social or political beliefs; it is well that this should be so, and that each ideal should be submitted to the hot fires of discussion.

There are almost innumerable agencies, more or less directly concerned in the practical working out of these ideals. The banking and related industrial interests in general are on the one side—on the other the labor organizations. Each is

urging from its own standpoint the adoption of certain policies with reference to the utilization of man power and of materials. Between them is the engineer who must make the plans to put into effect the line of action needed to produce the desired result. He should not be content to be merely the go-between but should guide and direct as may be possible from his relatively disinterested standpoint.

Under the head of ideals or plans may be grouped many problems whose solution depends upon the policy to be adopted by public and private bodies concerned with labor, commerce, industry, education and economics. These ideals and the problems dependent upon them afford a wide range of speculation or of idealism, but among these needs that of a national labor policy stands prominent as the prime requisite for reconstruction; and next to this, land, taxation and raw materials.

Dean Davenport has well stated that we are to address ourselves to the evolution of a real democracy.

> This evolution will submit to society for progressive solution, a series of detailed problems—every one difficult and every one coordinated with every other one, but all conditioned by the one object—the highest possible development of the human race. These issues will include such difficult problems as (*a*) an adequate land policy, (*b*) sanitary and comfortable housing, (*c*) good and abundant food, (*d*) public insurance against preventable or curable diseases for public reasons, (*e*) universal and free education that really educates, (*f*) economic opportunity, (*g*) industry and thrift either optional or enforced, (*h*) adequate provision for the helpless, (*i*) a clean public service, (*j*) a rational conception as between the individual and state, and between public and private ownership.
>
> There are a thousand related questions, local, national and international that will thrust themselves upon us for adjustment and more than that for readjustment, for we shall have the power to see only a little way at a time along the road that we shall then be traveling.[1]

Each of these policies is usually considered by the persons interested as a separate entity and one which may be discussed by itself. This is where danger lies to the country as a whole, namely, in that with lack of full information, there is inability on the part of the public to mentally visualize the relative proportions of each topic. For example, the settlement of soldiers upon reclaimed lands, important in itself, may lead to the obscuring of larger needs and to divert attention to the detriment of the best interests of the country as a whole. It is exceedingly important, therefore, that all of these problems be catalogued together and be viewed as a whole—as well as in detail.

It is the engineer who must supply many of the facts and conclusions upon which the policies may be based. Some of

[1] *Country Gentleman*, November 16, 1918.

the subjects above enumerated fall entirely within his cognizance, especially those pertaining to land, to housing and to the discovery and use of the natural resources.

Without the intelligent direction of the engineer, little progress can be made. The great war has awakened Americans to the fact that in their somewhat complacent attitude of mind they had permitted European nations, especially Germany, to far outstrip them, with the result that when war came suddenly upon us, we were compelled to lose time, and directly or indirectly sacrifice thousands of lives and millions of dollars in accumulated wealth because of our short-sighted policy with reference to engineering and to scientific research along engineering lines.

The whole subject of raw materials is also one which can be attacked successfully only by the engineer, including with these materials not only iron, copper, clay, petroleums and other substances from the earth, but also the fuels and other sources of power, such as from the flowing waters.

The engineer's problems of to-day also include that of transportation, not merely the building and operating of railroads, waterways and highways, and the cars or boats moving on these, but also the navigation of the air and all of the matters which lead up to successful performance.

Next in importance comes the means of communication—the telephone, the telegraph, the wireless, and closely connected with these the rapidly increasing number of public utilities, founded primarily on engineering plans and methods. It has been the fashion to leave the larger control of these to business men and lawyers, but the time is arriving when the engineer is appreciated to be the chief factor in their success.

In agriculture also the engineer has entered, and with the increasing demand for food, his skill is being more and more called upon, not only in developing agricultural machinery, but in building irrigation and drainage systems, in clearing lands, and in directing operations in a large way. In housing problems the engineer, as well as the architect, must direct affairs. Even in education and the diffusion of intelligence, the operations are becoming more and more closely connected with the principles of engineering.

In all of these matters which pertain to the conservation and use of the resources of the country, both material and human, and the development of ideals, the engineer should be active; while his profession may not include the direct control of capital and credit, of foreign and domestic trade, of agricul-

tural distribution, and of many purely business questions, yet he is, or should be, such a factor in the fundamentals of these that his knowledge and skill can not safely be neglected.

Assuming that the above statements of the engineer's part in after-the-war problems are approximately correct, then comes the question as to what he and his organization should do in the present crisis of world affairs. The reply seems obvious that as an individual he should take an active part in these world problems. Every engineering society should have its committee on reconstruction, charged with the duty of arranging for effective presentation of one or another of these great subjects of employment of labor, research, study of raw materials, or fuels, power, transportation, public utilities and other matters, all of which are undergoing radical changes. The trend of these should be studied and the influence of the engineer as an individual should be wisely used.

Each society under this conception has a great duty and responsibility to its members and through them to the public. The standing of the engineering profession in the near future must be determined largely by the wisdom of the action taken now in approaching these great problems of reconstruction.

BIOLOGICAL PHILOSOPHY AND THE WAR[1]

By Professor LEON J. COLE

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IN these terrible days when all the great advancements and discoveries of scientific achievement seem to be turned by man to the destruction of his fellow man, science itself stands indicted in the minds of many as the greatest curse that civilization has brought forth. While we do not perhaps hear it often voiced in such sweeping condemnation, it is not unusual that the same thought is applied to some particular invention. It was only a few days ago, for example, that I heard some one say it "seemed too bad that the mastery of the air had been achieved, since it could be turned to the bombing of innocent women and children." No doubt many of us unconsciously have had much the same thought when we have reflected on the nefarious manner in which scientific discoveries have in this war been prostituted to the end of accomplishing a desired purpose in contravention of all laws of humanity and of decency. Nevertheless, I wish to assert that this is plainly a prostitution of scientific discoveries and that science, as such, can not be condemned without a careful weighing of the benefits it has conferred on the race as a means of amelioration in the struggle against natural conditions—the elements, hunger and disease—the weighing of these benefits against the harm it has wrought when used as a tool for evil. While we can not perhaps assert that we are any happier than the savage in his ignorance, probably few of us would care to return to his state.

It is not my purpose, however, to make an apology for nor even a defense of science, neither of which is necessary. But it is a part of our scientific method to send our reasoning out ahead of our actual demonstrated knowledge; it is the advance guard which is sent forward to reconnoiter the unknown country in the attempt to find the true path by which the line of march shall follow. The results of this reconnaisance we call hypotheses and theories. Sometimes the correct route is discovered; often not; and more often still only partially, so that when we find ourselves in a *cul-de-sac* counter marches must be made

[1] Presidential address delivered before the Wisconsin Chapter of Xi, May 21, 1918.

and branch roads followed up. The directness and speed of our progress obviously depends in large measure on the correctness of our leads. Our advance is largely by the method so well known to the biologist because so extensively employed by the lower animals—that of "trial and error"; the extent to which it is more direct depends upon the correct reasoning and insight displayed by our hypotheses. Our hypotheses, then, are of very vital importance, since they often determine the course of our activities, and they may even furnish the principles by which we live and order our lives and affairs.

Now no line of scientific thought and endeavor has perhaps been more influenced by theory than that of biology, and the biological theories which have had greatest influence are those relating to the methods of organic evolution. The day is past when the fact of organic evolution is questioned, although biologists are still far from being in agreement as to the means by which it has taken place. But the gradual acceptance and spread of the doctrines of evolution have had an influence far beyond the domain of science—they first took a hold on the educated public, and have since filtered out through various channels until they have produced an appreciable effect on much that we think and do. Particularly have they put their impress on religion—or more strictly speaking on theology—and on sociology. This is as it should be in so far as well established facts are concerned; but if science in her newly acquired leadership should guide us falsely it would be a serious offense indeed.

The Germans are preeminently a people who take themselves seriously. What is more they take their science and their scientific theories seriously as well, and apparently these are playing a large part in the present world conflict, not only in the practical application of the former, but to an equal extent in the way in which the latter are used as a justification of the war and in the manner of its prosecution. This was brought forcibly to my mind in reading the recent admirable essays of Professor Vernon Kellogg published under the caption of "Headquarters Nights." Whatever may be the motives and ambitions of the military leaders, the so-called German intellectuals seem to have a definite philosophy which serves as a basis for their position—a position which they are not only ready to support by argument, but for which many of them are willing to fight. As Kellogg says, "they fight, not simply because they are forced to, but because, curiously enough, they believe much of their talk." And he adds: "This is one of the dangers from the Germans to which the world is exposed; they really believe much of what they say."

Those of you who have read the essays to which I refer will recall that Kellogg, while serving in Belgium and northern France on the Belgian Relief Commission, had abundant opportunity to discuss the German point of view with an old-time friend of his, a zoologist stationed at headquarters as a captain of infantry, whose identity Kellogg hides—though ineffectually to most biologists—under the fictitious name of Professor von Flussen. Kellogg says:

> The captain-professor has a logically constructed argument why, for the good of the world, there should be this war, and why, for the good of the world, the Germans should win it, win it completely and terribly. It is a point of view that justifies itself by a whole-hearted acceptance of the worst of Neo-Darwinism, the *Allmacht* of natural selection applied rigorously to human life and society and *Kultur*.

Kellogg goes on to say that in talking it out biologically they

> agreed that the human race is subject to the influence of fundamental biologic laws of variation, heredity, selection and so forth, just as are all other animal—and plant—kinds. The factors of organic evolution generally are factors in human natural evolution. Man has risen from his primitive bestial state of glacial time, a hundred or several hundred thousand years ago, when he was animal among animals, to the stage of to-day, always under the influence of these great evolutionary factors, and partly by virtue of them.

So far they agreed, but beyond this their ideas were irreconcilably at variance because of inability to accept the same premises for further argument. Accepting the German premises the argument goes on with irresistible logic to the inevitable conclusion. In order to put this before you, I can not do better than to quote again:

> Professor von Flussen is Neo-Darwinian, as are most German biologists and natural philosophers. The creed of the *Allmacht* of a natural selection based on violent and competitive struggle is the gospel of the German intellectuals; all else is illusion and anathema. The mutual-aid principle is recognized only as restricted to its application within limited groups. For instance, it may and does exist, and to positive biological benefit, within single ant communities, but the different ant kinds fight desperately with each other, the stronger destroying or enslaving the weaker. Similarly it may exist to advantage within the limits of organized human groups—as those which are ethnographically, nationally, or otherwise variously delimited. But as with the different ant species, struggle—bitter, ruthless struggle—is the rule among the different human groups.
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> This struggle not only must go on, for that is the natural law, but it should go on, so that this natural law may work out in its cruel inevitable way the salvation of the human species. By its salvation is meant its desirable natural evolution. That human group which is in the most

advanced evolutionary stage as regards internal organization and form of social relationship is best, and should, for the sake of the species, be preserved at the expense of the less advanced, the less effective. It should win in the struggle for existence, and this struggle should occur precisely that the various types may be tested, and the best not only preserved, but put in position to impose its kind of social organization—its *Kultur*—on the others, or, alternatively, to destroy and replace them.

Such is the argument, and it must be confessed that to a biologist familiar with the details of the ruthless "struggle for existence" among the lower forms of life its plausibility is at first most disheartening. Our first revolt against it is from the heart rather than from the head. It violates all our ideas of right and justice and of humanity. But the German philosophy has no room for dictates of the heart where the state is concerned—all principles of right and justice and of fairness are subordinated to the simple power of might when it is a question of the German government against any other people. This is simply the working out between nations of the primary law of natural selection.

Professor von Flussen says that this war is necessary as a test of the German position and claim. If Germany is beaten, it will prove that she has moved along the wrong evolutionary line, and should be beaten. If she wins, it will prove that she is on the right way, and that the rest of the world, at least that part which we and the Allies represent, is on the wrong way and should, for the sake of the right evolution of the human race, be stopped and put on the right way—or else be destroyed as unfit.

Could anything be simpler? That which is, or can be, is right!

Be it said in Professor von Flussen's behalf—and the same no doubt applies to others who share his belief—he is ready to stand by his doctrines.

If the wrong and unnatural alternative of an Allied victory should obtain, then he would prefer to die in the catastrophe and not have to live in a world perversely resistant to natural law. He means it all. He will act on this belief. He does act on it, indeed. He opposes all mercy, all compromise with human soft-heartedness. Apart from his horrible academic casuistry and his conviction that the individual is nothing, the state all, he is a reasoning and warm-hearted man. So are some other Germans. But for him and them the test of right in this struggle is success in it.

Now this reasoning on the basis of biological analogy—making rigid application of the rule of the "survival of the fittest" to human ethnological groups—has enough of plausibility about it to make it very disturbing. For those who are not biologists, or for those of us who feel that man is working his evolution out in a different way from that of the lower animals,

it is somewhat difficult to get the coldly practical German point of view. We are inclined to rate the finer feelings and impulses that man has developed as indicating the high water mark of his evolution; but from the viewpoint of German philosophy these are but defects unless they have a definite survival value. To us they seem the things that make life worth living, but what is to become of them if the people possessing them and acting upon them is at the mercy of and subject to destruction by any other nation which prefers to make its way by brute force? Clearly right must have might as well so long as it has to contend with those who recognize only might as an evolutionary factor.

If we admit that man is not beyond the workings of the fundamental laws of evolution, where shall we find the hole in the German reasoning? Kellogg suggests that it lies in the value of altruism, or mutual aid, as he prefers to call it in order to avoid anthropomorphic implications in speaking of it in the lower forms of life. He does not, however, develop the point, and his discussion is far from a demonstration. It is this phase of the subject which I should like to develop a little farther.

Leaving aside the question as to how new characters of form or behavior arise, biologists are in general agreement that the chances of survival are greatest for those organisms which are best suited to meet the conditions of life; in other words, show greatest adaptation to their environment. This means that in the long run such forms will tend to survive and reproduce, and presumably to increase the chances that their offspring will be possessed of the same advantages. The process is slow and bungling, but nature, by a prodigality of reproduction, throwing myriads of individuals into the discard and saving the few, makes her way haltingly but inevitably toward some unknown goal. This process of elimination is natural selection, and in Neo-Darwinian philosophy, which is also the German philosophy, this is the all-powerful force in evolution. The questions for us to answer if possible are: Is man subject to natural selection in the above sense? and what part does mutual aid play in his evolution?

Taking up the second question first, it may be well to give a very sketchy review of the beginnings and course of development of the mutual aid principle in the animal kingdom. In many of the lower animals, such for example as most of the protozoa, each individual is an independent unit which meets its environment and struggles with it alone, having no relation to other individuals of its species. It survives or perishes en-

tirely as its merits or special advantages enable it to cope with the chances besetting its existence. It has no social relation to other individuals except when, as a purely physiological reaction, a portion of its protoplasm may unite with that of another, resulting in new combinations of hereditary factors, and hence increasing the chance that something new may appear which will give some of its descendants an even greater advantage in the never-ending struggle to survive.

In certain groups aggregations or colonies of individuals appear, and these seem to have acquired by their association certain advantages. There is no need to enumerate all of these advantages, but one of the most apparent is the possibility of *specialization,* the taking over of separate functions formerly common to each independent individual by the different components of the colony. Thus we early find special individuals given over solely to reproduction, while the others retain their functions of locomotion, feeding and the like. Further developments of colonial social organization employ almost every imaginable advantage of specialization, such as entirely separate individuals for locomotion or support, for feeding, for apprehension or defense, and for special senses. It is a fascinating field and tempts one to go into details of special and beautiful adaptations, but for our present purpose the point I wish to make is that the colony is a new unit possessed of special advantages in its fight for existence, and superseding the individual. Indeed we may even have colonies of colonies, and no end of complicated adaptations. A second point I would make here is that practically all colonies are really *families*—the component members are all related, being the descendants of single individuals or pairs of individuals which have remained grouped together instead of separating as they were formed.

It has long been recognized by biologists that all many-celled animals—man among them—are, broadly speaking, colonies made up of individuals of a lower order. These individuals are the cells, which reach the extreme of specialization into tissues, having lost completely their power of separate existence and of reproducing the species. They are entirely dependent for their existence on the successful cooperation of the whole aggregate of tissues, each composed of its particular kind of individual cells.

The social relations so far discussed, using the word in its broadest possible sense, have all been between members of the same species. It is very common, however, for similar relations to be established between individuals or groups of different

species. Thus we have all degrees of commensalism, in which the advantages of the relation are mutual, and from that a series of relations ranging on the one hand to parasitism and on the other to virtual slavery.

It is easy in the sociological history of mankind to find essential parallels to most of the social relations that have been mentioned in the foregoing. How far back the individual man, or his progenitor, was an entirely independent social unit we have no means of knowing, but, as in lower forms, the family was without doubt the original group, arising naturally from the necessary association accompanying the increasing care given to the offspring, which has been such a potent factor in man's evolution. From the family group as the ethnic unit, we see gradual expansion of the unit to the group of families, or clan with a common descent, then to the village, the tribe, the small state, and finally to the nation as we are familiar with it at the present time. But the evolution of these various ethnic groups has not been in a straight genetic line. There have been the usual ramifications and divergencies that are common to all evolutionary progress. There have been some lines in which essential democracy was the rule, but more commonly specialization of labor has been accompanied by the development of a special governing class, while often at the same time a condition of serfdom, as exemplified in the feudal estates, or of slavery, has been imposed upon the subordinate members of the society.

The philosophy of the German state of to-day appears to be founded on the principle of ultra-specialization. It exemplifies the nation as the extreme development of the unit of evolutionary interaction. The reasoning is simplicity itself—the nation has merely become a greatly magnified individual in the struggle for existence. Its classes are its tissues. Its rulers are the central nervous system which guide and direct the activities of the whole, and just as nervous tissue is the most highly developed in the body, being specially set aside for its one function and incapable of any other, it is easy to see how the "divine right" of the ruling classes arises—it has been so decreed by nature. By the same divine edict, I presume, other classes are destined to remain the "hewers of wood and the drawers of water." And just as one tissue can not change to another, so on this strict specialization principle it is best for each class to develop for a particular function and to perfect that one function to its highest degree. There is no encouragement to advancement from one class to another, and least of all from the laboring class to the ruling.

The analogy might be extended to minute details, but there is no need. Specialization seems to be the key-note to all evolutionary advancement; the highest forms in each line of development are the most specialized, and man has reached his position of preeminence in the animal kingdom as a consequence of the highly specialized state of his nervous organization. If this principle holds for the individual as a unit, why should it not hold equally for the ethnic unit?

The next step is also perfectly logical. We have seen the ethnic unit grow in size until it is now a large nation, but still having in a way the attributes of a single organism in which the various parts, under the direction of a specially segregated coordinating and guiding part, all work together for the common good—meaning by good the survival of the unit. But why should the organization stop here? Why should it not expand on the same lines until we have a mammoth sociological unit—or, speaking biologically, an organism of a super-order—which shall include all mankind and whose rulers shall direct the destinies of the whole world? This is the dream of Pangermanism. And does not the logic proceed with a fatalistic beauty from the first colonial aggregation of one-celled organisms to a German world empire? There is no room for doubt in this argument that the empire must come; the only question is as to whether it is destined to be German, and this point the present war is to decide.

We shall have to admit that it is perfectly good scientific method to forecast future events from the record of the past, and if the foregoing reasoning is correct we as a people, and as a republic, have indeed been on the wrong path. But is it not possible that some pages in the history have been overlooked—pages with a significant importance for any forecast which may be made of the trend of social evolution? I believe this to be the case, and in particular I would call attention to two facts which might well be disturbing to the German viewpoint. The first of these is that nature has in the past ruthlessly condemned to unpitying extermination forms that have become overdeveloped and over-specialized. If we are to reason from analogy, why may we not similarly expect elimination of the over-specialized social organization? But a greater defect in the argument is that it over-stresses the analogy of man's evolution with that of organic evolution as based on principles established for lower forms. In forecasting from the trend of evolution it builds entirely on an academic formalism—an elementary textbook conception of organic evolution—and neglects the modifi-

cation which man himself has introduced by his mental development. We must not, however, forsake the solid ground of established principles for anything new which smacks of mysticism; we must, on the contrary, be ready to accept the challenge that the surviving line in evolution to-day, as in the past, and in man as in all animals and plants, shall have a definite, tangible survival value.

What I shall attempt to establish is that the most vigorous and promising trend of social evolution has been for some time toward democratic rather than toward autocratic forms of government. If it can be determined with reasonable certainty that such is the case, it will not be necessary to the argument to show *why* it is true any more than it is necessary to show why nature perpetuated the slow-moving tortoise and eliminated its flying relative, the pterodactyl. We simply assume because the one survived and the other died, that the former was for some reason better adapted to the conditions with which it had to contend than the latter.

Now democracies are not new, nor peculiar to recent civilization; they have appeared sporadically from time to time during the past centuries, but were usually short-lived. They commonly died out from one of two causes; either too large a proportion of their constituent peoples were not educated to the point necessary for self government, or the governments themselves were too weak to resist the encroachments of neighboring nations. Nevertheless the principle of participation in their own government by larger and larger classes of the people has been steadily on the increase, until in this day nearly all the larger nations are, to a very great extent, truly democratic. At the same time monarchies have been toppling and kings have retained their titles only by surrendering their power. Are we to believe that this process has reached its zenith and that the course of evolution is going to reverse itself? That is a thing evolutionary processes seldom if ever do. Even if autocracy should win a military victory in the present war, I am convinced that it would be no more than a rock in the way of an irresistible tide; it might retard the flow locally for a time, but it would eventually be surrounded and submerged.

Man no longer reacts by inherited instincts; he is supplied in their stead with a mechanism for reasoning, and this mechanism is generally distributed, albeit in varying degrees of perfection. So long as its development could be confined to one class that class was in a position to govern, and to keep all others in subjugation or slavery. Furthermore, by class mar-

riage, this condition tended to become hereditary, and to produce a society composed of a small intellectual ruling class and a large ignorant proletariat. It is conceivable that this condition might have become an established and permanent one; but a number of factors have worked against it. Time does not permit discussing them all, but two may be mentioned—the development of science and of the spirit of altruism.

The race value of the former is easily seen. Since man has been using his wits to thwart natural selection, he has taken advantage of every invention his ingenuity could suggest for that purpose. It increases the advantage to any social unit if all its members are able to utilize any new inventions, whether an engine of war or an implement of industry. The time has passed when they need be useful citizens only in the way a horse is one, for they must be trained citizens—they must have capabilities beyond those of the horse. To make the story short, as science and industrial development have grown hand in hand, more and more necessary has general education become, and as a people become educated they are almost certain to demand a share in their own government. It may be asked then, why have the German people as a whole been so backward in demanding a real participation in governmental affairs, for their education has been general and nowhere was technical development greater? Is it due to a different hereditary mental equipment on the part of the German, or is it his environment? This is a question on which one now reads and hears very positive statements every day; but the biologist at least should know enough to be cautious in drawing conclusions. In particular the student of heredity knows that the question of the relative effects of heredity and environment presents about the most difficult problems with which he has to deal.

To demonstrate the racial value of altruism is not so easy, but again the very fact that it has not only survived but has developed from insignificant beginnings seems to bespeak for it a survival value. When a mother bird or other animal gives her life in the defense of her young, it is difficult to see how she herself has profited thereby, especially, if, as is apt to be the case, the young are not old enough to care for themselves and consequently also perish. But we must believe that in the long run the behavior on her part which led to death is beneficial to her offspring and increases their chance of survival. Without going into the intermediate steps, it is doubtless the same instinct, highly developed and modified, which impels a man to risk his own life to save another—even a worthless one—and to

feel a sense of civic responsibility. We call it the right thing to do—which probably simply means that in the long run it is the sort of action that has had a survival value for the race.

Even the most ardent hater of all things Teutonic can scarcely deny that this type of behavior is developed as a personal attribute in Germany as elsewhere; but we believe it should be carried a step further and applied to nations as well as to individuals. Germany, on the other hand, as a state dealing with other states, has no place for altruism. Are we wrong, however, in believing that even though, as the occasional mother may be destroyed in defending her young, so some nations may be crushed in the present struggle, nevertheless a comity and brotherhood of nations is for the best ultimate good of all, and moreover that its consummation is the real prophecy to be read from the records of the past? At any rate the mother bird has something for which she is instinctively ready to fight, and so ought we to be ready to fight for those broader principles which we believe should govern the relation of man to man; for even though we may suffer individually, we are fighting to preserve the things for which we stand.

SOME PERILS WHICH CONFRONT US AS SCIENTISTS

By Professor FRANCIS B. SUMNER

SCRIPPS INSTITUTION FOR BIOLOGICAL RESEARCH

TO play the rôle of Cassandra is commonly to invite unpopularity if not contempt. The average, easy-going mortal (which means some ninety per cent. or more of us) is by nature an optimist, and he does not wish his optimistic reveries to be disturbed by forecasts of impending disaster. However, Cassandra's prophesies were true and Troy did fall.

The dangers which I am about to discuss threaten all of us who seek to learn the ways of nature without ulterior motive. To realize these dangers is the first step toward averting them. That they are not generally realized is only too evident to one who reads either the editorial opinions of the daily press or the more learned deliverances of his own scientific colleagues.

The perils of which I am about to speak are all manifestations of one great fundamental Peril, whose source lies deep in our current habits of thought and in our philosophy of life. This has been variously designated as "commercialism," "materialism" and "utilitarianism." Each of these words expresses one aspect of the truth, though each in itself is incomplete. Taken etymologically, the word utilitarianism conveys most nearly the idea which I intend to express, though I do not wish to identify this meaning with the ethical theory which has been known by that name.

This habit of thought is characterized by the glorification of *utility*. Its standards of value are "usefulness," "practicality" and "efficiency," or, in its crassest form, dollars and cents. Its dearest foes are the "theorists," the "idealist" and the "doctrinaire."

The reader may be smiling, perhaps, at my tardy discovery of a conflict of ideals as old as civilization itself, and at the naïve way in which I am uttering these platitudes with all the authority of a Hebrew prophet. Well, let us admit that what I shall say contains nothing very new in principle. But is it not true that all reforms are made possible through the reiteration of more or less familiar ideas, until at last they gain ac-

ceptance and are translated into action? Moreover, even if the main theme of my discourse is hoary with antiquity, the present world situation is without parallel in the past, and the dangers of which I speak are particularly menacing at this time. This is the more true because they are not generally recognized as real.

By many it is being joyfully proclaimed that science has at last come to its own. Has not the Great War shown to all the world, and shown with unmistakable clearness, the practical value of science to the nation? Has not the scientist in nearly every field of knowledge—the psychologist and the astronomer, no less than the chemist, the physicist and the bacteriologist—been called upon to play a vital part in the defense of his country and of civilization? That he has answered this call with credit to himself and his profession is one of the outstanding features of recent history. Professors and doctors of philosophy are now majors and captains in the army. The importance and variety of the services which they have rendered can not even be suggested in the space at my disposal. They have been interestingly summarized in various recent addresses and magazine articles.[1]

So far, this is all as it should be. That a scientist whose special training enabled him to aid materially in the national defense should have failed to devote his energies to this task in such a crisis would assuredly have betrayed a lack of elementary patriotism. And the depleted faculties of our universities are testimony enough that the call when it came was not unheeded. Indeed it now seems probable that this outburst of collective enthusiasm led many to drop valuable investigations of long standing and to embark upon unknown seas, in quest of very problematic returns. Be this as it may, the net results of this movement were of great and obvious importance to the nation.

Thus it comes to pass that even the man in the street no longer views the spectacled professor with the undisguised contempt of former years. The "high-brow" has at last made good. He has done something *useful!* So it may well be that within the next few years the professor will be able to meet his classes in garments a little less threadbare than heretofore, and that he will not need to beg quite so hard for the meager allowance upon which to run his laboratory. I even suspect that the legislator will now and then find himself besieged by

[1] For example, the article by Professor J. S. Ames in *Science*, October 25, 1918.

taxpayers, clamoring for the more generous treatment of so useful a citizen.

At such times as this the embarrassed scientist might well have recourse to the prayer: "Lord save me from my friends!" For it is to be feared that in his case, popular favor must rest largely upon a misconception of his real aims, and that it can only be sustained by tenderly nursing this misconception. Herein lies his greatest temptation. Will not the scientist come to listen more often than in the past to those siren voices which promise him financial support and social recognition? The investigator who accepts these with the tacit understanding that direct or indirect practical results are to follow from his labors is likely to find himself confronted by a dilemma. Either he will adhere to these conditions conscientiously, in which case his outlook and freedom of action will be seriously restricted, or he will fail to observe them scrupulously, and thus blunt that spirit of truthfulness which is his most potent instrument of research. Furthermore, he will sooner or later face the inevitable day of reckoning which will follow his failure to "deliver the goods."

At this point certain words of explanation may be necessary. I regard all work in science as being justified by its *value to humanity*. I should apply to it the same standard as to music, art or literature. If there really exists anywhere a scientist who works solely for the gratification of his personal appetite for knowledge, and who glories in the utter uselessness of his intellectual output to mankind, his suppression by society would be altogether justifiable. This is the more true since such a being would not merit the name of scientist. Science is, by nature, a social function. But such a grotesque caricature probably does not exist, at least outside of a lunatic asylum or the pages of comic literature.

Let us repeat then, science must be justified by its value to mankind. But we must recognize the existence of various standards of value. That there are standards far higher than those generally recognized and applied to this question is the main theme of my discourse.

A further word of explanation is desirable. I have no sympathy with the scientist—if such a one indeed exists—who regards scientific knowledge as being *tainted* by its application to the practical needs of life. The task of utilizing the forces of nature to the fullest, whether in saving our labors, increasing our pleasures or diminishing our pains, should be pursued relentlessly. And the student of nature who turns aside from

his quest for truth to offer his assistance in the making of any such practical application does not necessarily degrade himself or compromise his scientific ideals.

But here again we are probably dealing with a caricature rather than a reality. However that may be, the caricature is one that has so often been drawn that many in our midst have perhaps been led to believe in its actual existence. The real element of truth in the picture is the recognition by some of us of the dangers which may beset the path of the investigator who endeavors to combine "pure" and "applied" science. One of these dangers, already referred to, is the acceptance of financial support under conditions which must limit the investigator's freedom of action. Another is the insidious impairment of his intellectual honesty which sometimes results from an endeavor to cooperate with those who may entertain widely different standards of value and of truthfulness from himself.

We must now look a little further into this matter of standards of value. There was a time, early in my own life, when I decided for certain reasons to abandon the pursuit of biology as a profession and to study medicine. I well remember the warm approbation with which my decision was greeted by certain high-minded relatives of mine, on the ground that I should henceforth be working for the benefit of humanity. To merely extend the boundaries of knowledge seemed too much like a selfish pastime. Yet it is doubtful if selfishness of motive would have been imputed, had I shown talent along artistic lines and chosen the career of poet, musician or painter. The need of "applying" these latter gifts in any special way to the "benefit of humanity" is seldom insisted upon, at least by educated persons. They are, in themselves, credited with being elevating to mankind, and the artist's only duty in the matter would seem to be to give (or sell!) his creations to the public. Fortunately, as I now believe, I once more reversed my decision and have ever since continued unrepentingly in the humble quest of scientific truth.

In passing, one can not refrain from paying his respects to an educational system which refuses to recognize the cultural value of science, and which treats it—when it does not ignore it altogether—as consisting merely of useful precepts regarding the preservation of health or the basic principles underlying this or that skilled profession.

But in the long run, the scientist himself can not altogether escape responsibility for these misconceptions. He commonly recognizes no obligation to enlighten the public regarding his

activities, and when he does so he is only too apt to shamefacedly hide from view the real sources of his inspiration and to talk the same utilitarian lingo as the world around him. And from talking it, he may more and more come to believe in it.[2]

Much of the current defense of science, as voiced by some of its acknowledged spokesmen, and by the editors of some of our foremost scientific journals, seems to me to be sadly one-sided, if not actually disingenuous. We are quite prepared to hear our manufacturers talk of science as the "handmaid of industry," but it gives us something of a shock to find such an utterance as the following quoted with approval by one of our foremost astronomers. "Without the aid of science," we are told, "the arts would be contemptible; without practical application, science would consist only of barren theories, which men would have no motive to pursue."[3]

Let us grant that, other things equal, the scientific discovery which admits of practical application is of greater importance to mankind than one which admits of no such application. In other words, the practical application may bestow a certain added value upon an otherwise important discovery. But this is far different from making practical applicability the sole criterion of the importance of a given bit of knowledge. One might well seek for the *practical applications* of the Copernican theory of the heavens, or the doctrine of organic evolution, albeit both of these hypotheses have revolutionized our habits of thought and our outlook upon the world in which we live.

I can not admit for a moment, indeed I feel it my duty to combat with whatever force and logic I can muster, the contention that practical applicability, in any commonly accepted meaning of the terms, is to be regarded as the fundamental standard of value in judging of the importance of scientific discoveries. If the meaning of these terms is to be so extended as to cover any form of benefits, mental, moral or material, which may accrue to mankind from the growth of natural knowledge, we could, of course, no longer reject this as the all-sufficient standard of value. But such a perversion of meaning would not make for the interests of clear thinking. Far from it, we should confuse an issue which is now a tolerably clear one.

[2] See the quite pertinent remarks of Dr. W. J. Crozier on this subject (*Science*, August 23, 1918).

[3] Quoted by Dr. George E. Hale, in an address under the auspices of the Engineering Foundation (*Science*, November 22, 1918).

In an extremely interesting recent volume, entitled "Science and the Nation,"[4] there are brought together the views of more than a dozen prominent English investigators, chosen from nearly as many different fields of pure and applied science. The writers herein consider this very question of the outlook for "pure" science after the war. Each of them insists upon the necessity for a fuller recognition of science by the nation, if the British Empire is to maintain its preeminent position in the world. Some of them are eloquent in demanding absolute freedom for the investigator to pursue his researches, regardless of their practical consequences. It is refreshing, for example, to hear a metallurgist speak in such language as this: "If the practical spirit—important and valuable as that is in its right place—is permitted to rule our research laboratories, it would be apt to sterilize our investigations and to rob us of the very fruit at which we should be trying to snatch."[5] And again we are warned by the same writer that "'research,' undertaken with a directly practical object, may actually hinder progress rather than assist it."[6]

Throughout all of these pages, however, the practical applications and inventions are treated as the real "fruits of science," which are to be attained in these devious ways.[7] "The game [in this particular case the useful knowledge of disease] has to be stalked from long distances and often by circuitous routes."[8] "Men who prove themselves especially adapted to purely scientific work must be subsidized in order that they may be able to devote themselves entirely to the task of scientific discovery."[9] *Why?* Because it is this "experimental investigation towards abstract ends which has furnished such gigantic contributions to the world's wealth during the past century."

In other words, it would seem that, even to this group of university scientists, the study of natural phenomena derives its ultimate justification from the useful by-products which it yields.

[4] Cambridge University Press, 1917.

[5] Professor Walter Rosenhain, p. 77.

[6] *Ibid.*, p. 56. See, also, similar remarks in address by Dr. C. E. Kenneth Mees, director of the Research Laboratory of the Eastman Kodak Company. (*Science*, June 2, 1916.)

[7] Professor W. H. Bragg, p. 25. This is also the burden of Ex-President Eliot's address on "The Fruits, Prospects, and Lessons of Recent Biological Science," delivered as president of the American Association for the Advancement of Science (*Science*, December 31, 1915).

[8] Lord Moulton, introduction, p. xvii.

[9] Professor W. J. Pope, p. 23.

We must remember, of course, that this volume was written during a great national crisis, when all the forces of the empire had to be mobilized for the purposes of defense. And we must remember too that the stagnant condition of the applied sciences in England was to a considerable extent responsible for her early military reverses. But with all due allowance for these circumstances, it seems to me that science has not received fair treatment at the hands of her own votaries.

The journal *Nature* has, for years past, been filled with stirring pleas for the public support of scientific investigation and scientific education in England. These pleas have doubtless been sadly needed, though there seem to be substantial reasons for hoping that the nation is at last becoming disposed to heed them. It is depressing, though perhaps at this time inevitable, that these appeals on behalf of science should rest their case mainly upon its contributions to the national wealth and national defense.

The friends of knowledge for its own sake will watch with the greatest concern to see whether these utilitarian motives will continue to dominate the scientific life of England now that the hour of peril has passed. For the war has really done nothing more than to accentuate a point of view which seems to have been gaining ascendancy for years past, in our own country as well as in England. We have long been accustomed to justify the comparative freedom which we sometimes accorded to our investigators on the plea that useful results turned up in all sorts of unexpected places, and that one could never tell in advance what lines of research would prove to be profitable. Add to this the unfortunate circumstance that the scientist was known to be an intractable sort of a being, who had to be allowed to gratify his perverse curiosity in order to keep him in the harness at all.

A writer in the New York *Evening Post* has expressed so well my own point of view in this connection that I can not refrain from quoting him rather fully. He says:

> There can be no doubt that the gospel of relentless "efficiency" to which the war has given so great an impetus carries, deeply embedded in it the seeds of hostility to all activities and interests which find their spring in intellectual aspiration or enthusiasm. At best, from the standpoint of the efficiency cult, such endeavors have to be justified by the plea that, divorced as they may seem to be from practical objects, they do conduce to the advancement of the common ends of the nation or of mankind, though the connection may be remote or subtle. The plea can be made good over a very broad area. . . . But the argument is a thorny one; and that is not the worst of it. The mere necessity of resorting to

such a defensive plea, the mere surrender of the proud conviction that the pursuit of truth is in itself a noble end which requires no secondary justification, must immeasurably depress the tone of scientific enthusiasm and impair the energy with which its objects are pursued.

And it has to be confessed that, long before the war began, . . . another factor was working powerfully toward the production of the same effect. For years, and most of all in this country, the idea that "service" is the only justifiable motive of intellectual endeavor had been steadily gaining ground.[10]

Before detailing further the harmful results of such a utilitarian justification of science, let us pause to examine the philosophy which underlies it.

Those who hold this view of the mission of science in the world resort continually to such expressions as "usefulness" or "benefit to humanity." Now we might, it is true, so stretch the meaning of the word "useful" as to cover all of our so-called "spiritual" needs. Thus Professor Gamble tells us that "the function of pure science is to pursue *useful* knowledge," but he goes on to say that "by useful knowledge is meant knowledge which contributes to the moral, social, intellectual, æsthetic, and material welfare of mankind."[11]

Well, this may be what Professor Gamble has in mind when he uses the word "useful," but the world in general will not so understand him. As I have already said, such language merely tends to befog the issue. The "uses" and "benefits to humanity" which the public at large expects to derive from the labors of the scientist are inventions and applications to the practical affairs of life.

It is not at all evident why "fruits" of this type should be acclaimed as benefits to humanity, while weighty contributions to our understanding of nature should be put aside as mere luxuries of the mind. Nor can we comprehend why the author of a useful invention should be hailed as a philanthropist (in addition to the financial rewards which he receives) while the student of basic principles should be looked upon as a selfish recluse.

One is tempted, now and then, to affect an air of Socratic interrogation and to ask the *use* of some of these practical achievements. Suppose that we do, for example, succeed in shortening by six hours the journey from New York to Chicago, or in lengthening by five years the average span of man's life, or in making two blades of grass grow where one grew before. What shall we do with those extra six hours or five

[10] New York *Evening Post* (article reprinted in *Science*, March 2, 1917).

[11] "Science and the Nation," pp. 113, 114.

years, and what will the increased population do which is made possible by a greater food supply? It may all mean a merely *quantitative* increase in the total amount of living—by no means a self-evident advantage, according to my way of thinking. The great mass of humanity is engaged in discharging the purely vegetative functions of the social organism, in keeping alive the individual and the race, and in maintaining a certain low minimum of comfort. To merely increase the total amount of this vegetative activity in the world seems to be widely accepted as one of the chief goals of human endeavor. And this belief appears to underly much of the utilitarian appraisement of science.

Then too, what of all these achievements in the way of adding to our comforts and diminishing our sufferings and superfluous labors? Important as we may grant these to be, their value, after all, is largely of a negative sort. They consist, for the most part, in the removal of obstacles to a fuller life and higher development. They in themselves contribute but little directly to that development. The labors of the scientist, along with those of the artist, the poet, the philosopher and some others, do contribute directly to it. But our utilitarian defenders of science arrogate to themselves the credit for a broader humanitarianism than that which inspires the labors of the mere seeker for truth. The whole issue really depends upon one's conception of what is most worth while. Which is the higher aim—to make room in the world for the greatest possible number of human animals, or to make the world a more interesting and intelligible place to live in: to feed the belly or to feed the brain?

True it is that the alimentary needs must first of all be met, and that they are, for a large section of humanity, still quite inadequately provided for. But let us never forget that alimentation is a means rather than an end, that the consumption of coal is not the real reason for the steam-engine's existence.

I can not leave this subject of the higher services of science without calling attention to an aspect of the matter which has received inadequate attention. Science has frequently been charged, not only with being irreligious, but with being unmoral, if not actually immoral in its tendencies. But strong arguments for the ethical value of science have been presented by various writers. Thus Professor E. P. Lewis, in an admirable recent article,[12] dwells upon the elevating effects of the scientific habit of mind on character.

[12] "The Ethical Value of Science" (SCIENTIFIC MONTHLY, November, 1918). See also address on "The Higher Usefulness of Science,"

The scientist has the same human failings as other people; he may have no better intentions nor be more righteous-minded than they; but he can sometimes act more intelligently in carrying out his good intentions. Science teaches us to seek the truth without prejudice; it develops the habit of disinterestedness; it leads us to consider all known elements in making ethical judgments; it prompts us to seek the amelioration of the health, the well-being, the happiness, of our fellow men; it diverts our vision from the fruitless contemplation of a past in which we can play no part to the present wherein lies our task; and it bids us to consider the future and the welfare of generations still unborn.

Professor Lewis points out, furthermore, the "real danger that too much stress may be laid on [the] material aspects of research, which are not science, but only its by-products." And he holds it to be "important for the interests of society that teachers of science should lay more emphasis upon its intellectual and ethical significance."

Let us consider further some of the baneful effects which may be expected to ensue from the adoption of this narrowly utilitarian view of the mission of science. It is generally agreed that the Great War is likely to have, as one of its sequelæ, a heightened activity along scientific lines. This, by many, is being acclaimed as part of that silver lining which every cloud is supposed to possess. But there are grave dangers in the situation, as I have already tried to indicate. For the kind of scientific activity which was stimulated by the war was inevitably utilitarian in the crassest sense of the word. The ends in view were military, industrial and sanitary. Researches along those lines which we rather inappropriately term "pure" science, suffered from the withdrawal of support and from the transference of the investigator's attention to more urgent needs. To what extent is this shifting of emphasis irreversible? The investigator who continues along the newer paths will doubtless be following the line of least resistance. He will have all the force of public approval behind him. And this is a powerful force when brought to bear upon a social being. The investigator may, to use the words of Dr. Raymond Pearl, come to "supplicate the great goddess Truth with one ear closely applied to the ground."

Again, the Great War has taught us, as never before, the power of organization. German organization came perilously near to conquering the world. It was only the tardy adoption of similar methods of organization by the Allied Powers that finally won the day for democracy. Hence it is that "individ-

by Professor W. E. Ritter, contained in volume having the same title (Richard Badger, 1918).

ualistic" ideas seem to be thoroughly discredited for the time being, and that something like a mania for organization is sweeping over the world, at least so far as we may judge from conditions in England and America.

Says Professor H. E. Armstrong: "Science must be organized, in fact, as other professions are organized, if it is to be an effective agent in our civilization."[13]

The editor of *Nature* tells us that

> in no class of work involving many workers can we dispense with organization. An army is not a collection of armed individuals. . . . The present method of conducting scientific research is a go-as-you-please method, in which each man does what his own inclinations suggest to him or the means at disposal allow him to do. . . . We have to get rid, in every department of work . . . of waste, inefficiency and make-believe or valueless products. We have to get rid of them in scientific research as well. This can only be done by limiting the individual initiative and adopting greater and more carefuly thought-out cooperation.[14]

The Committee of the Privy Council for Scientific and Industrial Research for the Year 1915–1916 voices the opinion that "effective research, particularly in its industrial applications, calls increasingly for the support and impetus that come from the systematized delving of a corps of sappers working intelligently, but *under orders*."[15]

A sub-committee of the Committee of One Hundred on Scientific Research, in our own country, thinks fit to point out, in referring to a staff of investigators in a research laboratory, that "the individual can exert only a very small influence except as a member of an organization or institution."[16] To this last assertion a critic has replied: "One wonders what institution or organization Newton or Darwin belonged to, without which 'they would have exerted only a very small influence.'"[17]

Now I do not intend to stultify myself by calling in question the power and the value of organization, at least when properly applied. The process of evolution, the passage from a lower to a higher state of being, is measured in terms of organization, and in this process the integrating or coordinating factor is no less important than the specialization of parts or of individuals.

[13] *Nature*, October 22, 1914.

[14] *Nature*, November 11, 1915.

[15] *Nature*, September 7, 1916 (Italics mine).

[16] *Science*, January 12, 1917. Such opinions could be multiplied voluminously. Some recently published remarks of Ex-Senator Elihu Root (*Science*, November 19, 1918), might be cited as extreme examples.

[17] *Science*, March 2, 1917 (anonymous).

But, as has often been pointed out, there are limits to the value of the conception of society as an organism. The biological organism acts as a unit, without any agreement of its parts so to act. There is but one guiding intelligence, which dominates the whole. Society, on the contrary, possesses as many intelligences as there are individuals, even though many or all of these may think best at times to surrender their own freedom of judgment and to be guided by the decisions of others. Society may act as a unit, but it can never think as a unit. This is true even in those rare cases when most of its component members chance to be stirred by the same idea. However much one mind may influence another, thinking is an individual and not a collective function. And we are all agreed as to the homage due to the genius, whose mental achievements owe the least to suggestions from his fellow men.[17a]

Intellectual activities may be "organized," of course, in the sense that a group of individuals may cooperate toward the attainment of some specified end. And it may at times further this common cause if the component minds delegate a certain part of their own initiative to some higher "coordinating center." Such an arrangement as this, indeed, may be the most efficient way in which to utilize the activities of a group of mediocre minds. But it is obvious that what is gained in collective efficiency is lost in individual spontaneity. The arguments by which we seek to justify democracy versus autocracy, in political life, apply to a large extent here. Be that as it may, it is significant to note that practically all of the really revolutionary discoveries in the history of science have been made by individuals, working not in solitude, it is true, but likewise not bound by any scheme of cooperative effort, involving others than themselves.

One of the chief risks inherent in any extensive cooperative scheme of scientific research is the fact that one may readily come to spend most of his time in "cooperating," and have little time left for the discovery of facts. Another grave danger has been pointed out clearly by various recent writers. Organization may readily open up the way for the activities of a type of executive whose influence is largely inimical to the true spirit of science. This executive may be a more or less successful man of science who becomes ambitious for wider powers, or he may belong to the purely administrative or business class. In either case, he is likely to be autocratic in his

[17a] I am not aware that any serious attempt has been made to *organize* the creative efforts of our painters, poets or musicians.

temper, and to regard the organization over which he presides as an instrument for carrying out his own ideas. If, as may well happen, these ideas contemplate real advances in scientific knowledge, the chief damage done is to the morale of the investigators, whose powers of original work can not fail to be impaired.

But if we have to do with the purely business type of executive, matters will be far worse. Such a one is almost certain to be a utilitarian, in the sense in which I have been using this term. That is, he will look upon scientific research as justified merely by its direct or indirect practical results. He will apply business criteria in his estimates of the men under his supervision, and will grade them in large degree according to the salaries which they are willing to work for. He will be disposed to assign an undue importance to his own administrative function, and to think of the investigators under him in much the same way as the factory superintendent regards the "hands" who operate the machinery.

So extreme a condition as this is, it is true, probably seldom realized. Such an executive would soon learn by experience, even if his business instincts did not teach him better at the outset, that a state of affairs like this would defeat his own ends. But, subject to such modifications as a higher prudence would dictate, the general situation could not fail to be much as I have outlined it. Indeed, it is safe to say that conditions approaching this have been realized over and over again in our state or national research institutions and even in some of our universities.

Let me quote the words of a man who, as we all know, is no mere doctrinaire scientist, but who himself holds a responsible administrative post. Dean Eugene Davenport, of the Illinois Agricultural Experiment Station, has devoted several pages to a scathing indictment of what he terms the "cult of administration."[18]

"The rate and the intensity with which administration under one pretext or another is coming to dominate research in this country, especially along agricultural lines, is," he tells us, "little short of appalling to any candid observer who takes stock of the situation and who has the courage of his convictions." He then proceeds to narrate in picturesque terms how the investigator's hands are tied and his spirit crushed by the exacting demands of officialdom.

[18] Address of the chairman of Section M (Agriculture) of the American Association for the Advancement of Science (*Science*, February 16, 1917).

In summing up the situation, he insists—this practical man of affairs—that

> administration can not vitalize research. Its whole effect is restrictive and hence should be reduced to a minimum. . . . All progress in science is the result of individual interest, initiative, invention and energy, all of which must be resident in the worker. The driving force that brings results is internal, not external, to the explorer after new truth. It beckons from ahead and does not prod from behind. . . . Administration does no work. It is a harness put upon activity. Its purpose is not to actuate, but to restrain and forbid. . . . The effect of too much administration upon the scientific worker is at first one of disappointment, then of discouragement, and finally of disgust. Conditions as they are now developing not only constitute an unhealthy example for our young men in college, but they are deterring thoughtful men from entering the public service.

Modern efficiency standards are not applicable to research. "Under what project," queries this same writer, "did Darwin work? Did Faraday report regularly upon the progress of his mental wanderings after firm resting places?"

Now that much heralded "cooperation in science," which is to regenerate the world, might not of necessity bring in its wake all of these evils of administration which Dean Davenport depicts. But there can not fail to be a strong tendency in that direction. All this may be said with a full recognition of the necessity for that stimulus which comes alone from contact with others having kindred interests. Isolation means intellectual stagnation. "The solitary scientist is likely to put a great part of his life into pathetic futilities" (Elihu Root). It is inconceivable that any group of specialists in allied fields should be thrown together in close association without there resulting much valuable interchange of thought, even if this did not take the shape of actual formal collaboration in their researches.

We may go further and grant that many important problems of science can only be solved through deliberate, cooperative effort, and that the extent and importance of such cooperation is bound to increase with the growth of civilization. But the dangers of this tendency should none the less be fully recognized. In general, it would seem that each case should be decided upon its own merits. Those who contemplate any particular cooperative program should, it seems to me, first ponder well the question whether the increasing degree of administrative routine and the suppression of individual initiative would not more than outweigh any compensating advantages.

In these days of national prohibition, press censorship and

espionage acts, I realize that "personal liberty" is no longer a slogan which will arouse much public enthusiasm, and I am quite aware that "individualism" and "*laissez-faire*" have latterly become terms of reproach. But there seems to be a decided danger that we may go to the opposite extreme. I have before me an article in the *Independent*[19] by a prominent university president, and another in the New York *Times*[20] by an anonymous "university professor now in the service of the United States." Both discuss the recent reorganization of American universities in the interests of the Students' Army Training Corps. And both voice the fervent hope that this experiment in militaristic paternalism will be continued indefinitely after the close of the war.

Indeed the writer in the New York *Times* assures us with the utmost complacence that it *will* be continued. Young men —and women too—will henceforth be drafted as paid cadets into our universities, which will remain governmental institutions. The courses pursued by each of these "student soldiers" will be prescribed according to his individual needs and abilities, and "non-essentials," or subjects for which he is not particularly fitted will be stricken from his curriculum. Upon the rating which he scores in his various tests of ability will depend, not only his military rank in the great citizen army, but his preparation for a business or professional career. "Nor will a professor, who [as an army officer] has learned to command and to obey, allow the old easy-going *laissez-faire* doctrine to permeate his lecture hall or laboratory," for military discipline, now that we have learned it, "won't soon be forgotten even in our classrooms." This "all looks like a Utopian scheme," concludes our writer, "but already we are doing it, and acquiring the habit."

Heaven help this Republic if our sons and daughters are to be trained for life as khaki-clad marionettes!

What, then, seems to be the duty of the man of science in the face of these dangers which threaten him both from within and without? To begin with, I should say, he should have the courage of his convictions. There is no question that he has often wavered in his faith in the importance of his own mission. The competent investigator who decides to practice medicine or to undertake elementary teaching for the reason that

[19] October 5, 1918. In a later article (Dec. 14, 1918), President Thwing has, it is true, laid considerable emphasis upon some of the "losses in educational values arising from this revolution."

[20] October 20, 1918.

he "wants to do some good in the world," may be actuated by praiseworthy motives, but he is sadly lacking in appreciation of his own high calling.

Once more, unless his real interests and abilities lie in the field of practical application, the scientist should steadfastly refuse to compromise with the utilitarian spirit, even though he thereby forfeits social recognition and financial support.

> With the reinforcements which the developments of the war have from so different a quarter brought to this tendency, it is more than ever necessary for those to assert themselves who know how precious to the life of us all is that element which is supplied by the devotion of the lives of some to the pursuit of truth for its own sake, or even for the sake of the fame which is the natural reward of signal success.[21]

Let those few fortunate ones who control the disposition of funds given without hampering restrictions sturdily refuse to divert these funds to utilitarian ends. A glance at the budgets of some of the organizations engaged in industrial and agricultural research in this country is conclusive proof that this type of investigation may be trusted to take care of itself.

There are, we are reliably informed, upwards of fifty corporations in this country, the annual expenditures of which on research range from $100,000 to $500,000.[22] The General Electric Company expends annually on research from $400,000 to $500,000, and has a laboratory staff numbering 150. The laboratory of the Eastman Kodak Company cost $150,000, and its annual cost of maintenance is about the same. The Mellon Institute of Industrial Research spends $150,000 annually on salaries and maintenance, and its buildings and equipment cost over $300,000.[23]

Passing to those of our government departments which conduct scientific investigations, the Department of Agriculture, in 1915, spent about $25,000,000, largely for research and education; the Bureau of Standards is said to spend annually about $600,000; the Bureau of Mines a nearly equal amount, and certain other bureaus expend smaller, though very considerable, sums.[24] Our 52 state agricultural experiment stations have a total revenue of some $5,000,000 annually.[25]

How trifling, in comparison with these immense sums, are the amounts which are devoted to the quest of knowledge with-

[21] New York *Evening Post*, quoted in *Science*, March 2, 1917.

[22] *Nature*, March 23, 1916.

[23] *Nature*, August 9, 1917. More recent figures are not accessible to me, but these expenditures have doubtless increased.

[24] *Nature*, May 31, 1917.

[25] *Ibid.*

out ulterior ends! To jealously guard that little from the encroachments of utilitarianism can not reasonably be imputed to any spirit of hostility to the practical utilization of scientific discovery. I think it the only tenable position at present for one who has a proper conception of the worth of science and who realizes the dangers which beset it.

Finally, it is the duty of the scientist to assume responsibility, as never before, for the enlightenment of the public upon the aims, the achievements and the real value of science. In this educational appeal, let him lay his chief stress upon the steady deepening of our insight into nature and life which science has given us. Let him show, as he of all persons should be best capable of showing, the bearing of his own special discoveries upon these wider realms of knowledge. But let him set aside once for all the wretched make-believe that these discoveries derive their real justification from the fact that they may in some remote way help to stimulate invention or put money into some one's pockets!

SOME PROBLEMS OF GAS WARFARE[1]

By Dr. ELLWOOD B. SPEAR

THE initial use of gas by the Germans at Ypres in 1915 and the subsequent adoption of gas warfare by the allied armies introduced a large number of problems of vital importance to the nations involved in the World War. While these problems taxed to a very great degree the ingenuity of the scientist, the engineer, the military strategist and the manufacturer, they by no means lacked that fascination which characterizes all research, an intellectual journey into the unknown. Although this fascination was augmented by the fact that the problems were nearly all new and the field almost limitless, nevertheless the flight of the imagination was circumscribed by the stern condition of immediate practical utility and the necessity for rapid solution.

Another feature especially prominent in the early stages of gas warfare was the unstable nature of the problems. The act on the screen was continually changing. The solutions of yesterday might not meet the requirements of to-day, and the practise of to-day might become archaic by to-morrow. The kaleidoscopic nature of these changes can be best illustrated by a brief account of the tactics of the offensive and the development of the defense, the chief feature of which is the gas mask.

The first object of the use of gas by the military strategist was, of course, to destroy the enemy. With this purpose in view the Germans made their first gas attack by means of poisonous clouds. Chlorine was compressed into cylinders that were placed in their own front-line trenches. The cylinders were fitted with a suitable hose and nozzle so that at the appointed time the valves could be opened and the gas allowed to escape. Chlorine is particularly adapted for this method of attack. It is fairly easily compressible into the form of a liquid, but six atmospheres being necessary at ordinary temperature. It is very poisonous, one to two parts per ten thousand of air sufficing to result in death if breathed for five minutes. It has the additional property of being heavy, about two and one-half times the weight of an equal volume of air. Consequently it does not tend to rise rapidly into the upper air, but, on the con-

[1] Figures 1 to 8 inclusive are published with the permission of the Director of the Chemical Warfare Service.

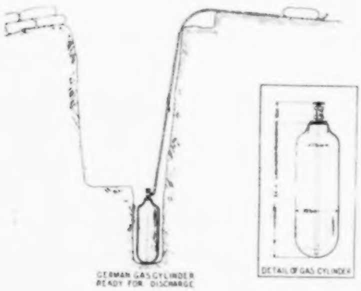


FIG. 1.

trary, rolls along the ground, seeking out and filling all the low places such as trenches, dugouts, shell holes and so on.

The result of the attack is now a matter of history. The French Colonial black troops broke and fled. Who can blame them? The Canadians went into this particular sector twelve thousand strong. When they were relieved five days later but two thousand remained alive. A very large portion of the ten thousand died as a result of the effects of the gas. In fact, had it not been for the presence of mind of some of the officers who ordered the men to put wet cloths over their faces and lie flat on the ground face downwards the entire force would have been annihilated. Fig. 1 shows a German gas cylinder in position in the trench.

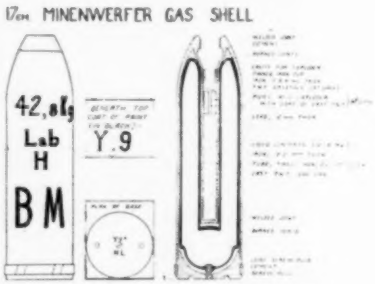


FIG. 2. GERMAN GAS SHELL.

Although successful at times this form of gas warfare was seldom used in the later stages of the struggle, owing to the inherent disadvantages of the method. In the first place the wind must obviously be in the right direction. It must not be too strong—less than twelve miles per hour—or the gas will be whirled about and dissipated before the goal is reached. It must not be too low or it may change its direction, in which case the offense may suffer more than the defense. In the second place, the greatest concentration is at the wrong end, directly before the trenches of the attacking party. Consequently if the gas is to be followed by an infantry attack the offense must endure more than the defense, or the attack must be delayed until most of the opportunities created by the gas are lost. A much more effective method depending upon the wind was being developed by the

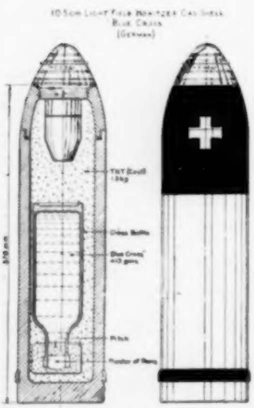


FIG. 3. GERMAN GAS SHELL.

American gas offensive, the details of which are not yet for publication.

It was soon realized by both sides that some more dependable means must be devised to create an efficient concentration of gas in the enemy's territory and the development of the gas shell is the result of these researches. Figs. 2 and 3 give schematic views of German gas shells. Gas shells are made for both large and small caliber guns. The former may deliver several quarts of the poisonous liquid at a single shot.

For certain kinds of work, gas shells have a great advantage over even the high-explosive variety. The latter may kill by direct hit or by the subsequent explosion. The former may do all this; but in addition the liberated gas may be carried to considerable distance from the spot where the explosion takes place and gas the enemy who has been protected from the high explosive by dugouts, etc.

However, the disastrous effects of both the gas cloud and the gas shell are largely offset by the high efficiency of the modern gas mask, and this brings us to the second object of the military strategist, viz., to annoy and hinder, or in military parlance, to "neutralize" the effectiveness of the enemy. It will be obvious even to the casual observer that the ability of the soldier to serve a gun, to shoot or to transport supplies is greatly reduced if he is obliged to wear a gas mask. In point of fact it is claimed by military men that the effectiveness of artillery is cut down sixty per cent., while the infantry fares scarcely any better, two men being required to perform the functions of one unhampered by this impediment.

For purposes of "neutralizing," ordinary poison gas may of course be employed. An occasional gas shell will prevent the enemy from removing his mask, but his life may be rendered almost unendurable by many substances really not gases in the accepted sense of the term. Lachrymators or tear gases, such as benzyl bromide, are heavy liquids which when sprayed over the ground in small quantities by the explosion will cause a copious flow of tears for hours if the eyes are not protected by the gas mask or other device. Moreover the celebrated "mustard gas," also a heavy liquid, will cause burns on the skin of such a vicious character that the soldier may be incapacitated for months. A partial list of gases that have been employed on the battlefield is given below.

Gas Clouds:

Chlorine.

FIG. 4. AN AMERICAN SOLDIER WEARING A CAPTURED GERMAN RESPIRATOR. The face piece is made of leather.

Shells:

Phosgene.
Sulfur trioxide.
Benzyl bromide, German T-Stoff.
Xylyl bromide, German T-Stoff.
Dichloro-diethysulfide, "Mustard Gas," German Yellow Cross.
Diphenyl-chlorarsine, "Sneeze Gas," German Blue Cross.
Trichlormethyl-chloroformate, German Green Cross.
Monochlormethyl-chloroformate, German K-Stoff.
Nitrotrichloromethane, "Chlorpicrine."
Brominated-ethyl-methyl ketone.
Dibromo-ketone.
Allyl-iso-thiocyanate.
Dichlormethyl ether.
Phenyl carbylamine chloride.

Hand Grenades:

Bromacetone.
Bromine.
Chloracetone.
Chlorsulfonic acid.
Dimethyl sulfate.
Methyl-chlorsulfonic acid.

THE DEVELOPMENT OF THE GAS MASK

When the Germans launched their first gas attack they were provided with a crude and inefficient device similar to the one shown in Fig. 6. Later they developed a much more serviceable mask as represented in Figs. 4 and 5. The British, as already stated, first employed a wet cloth. Even damp earth was found to have some virtue as a protection against gas. In a very short time English scientists had devised several types of respirators. These consisted chiefly of cotton wool soaked in photographer's "hypo" and washing soda. The deleterious effect of the latter upon the skin was reduced somewhat by adding a small amount of glycerine. The wool was attached to a cloth that was bound

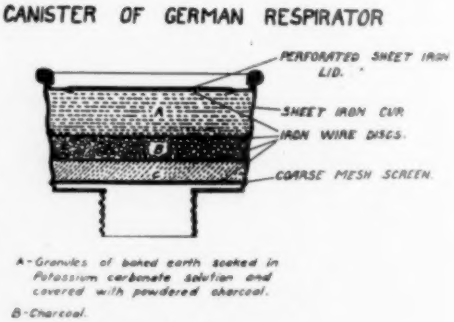


FIG. 5.

around the mouth and nose, as shown in Fig. 6, or it was held in the mouth until the cloth could be placed in position. The wool was then shoved up around the nostrils. These primitive masks would stop a considerable amount of chlorine if properly cared for and adjusted. Unfortunately the soldier too often dipped them in the solution and did not sufficiently wring out the excess liquid. As a consequence he could not breathe freely, thought he was being gassed, and frantically repeated the operation, often equally unsuccessfully. Moreover, the masks were not carried upon the person, but rather were placed in the trenches so that the soldier usually got one that had been worn by some one else. Beside the obviously unsanitary arrangement, another disadvantage presented itself. When the alarm was given several men frequently rushed for the same mask with the inevitable result that some of them were gassed.

Fig. 6. Early British Respirator.

A very decided improvement was next introduced in the form of the "smoke hood." Fig. 7 shows one of the latest models of these fairly efficient masks. Its great advantage lay in the fact that the breathing surface was large, resulting in a very material decrease in resistance. Another prominent feature was the valve that allowed the exhaled air to escape. It is made of rubber and is called technically the "flutter" valve. So successful is its operation for this purpose that it was subsequently adopted in the latest types of both British and American box respirators.

Fig. 7. British Smoke Hood.

It was soon realized by scientists that while "hypo" and alkalis would take care of chlorine and hexamethylenetetramine would stop large quantities of phosgene, many other gases, such as the chemically sluggish

FIG. 8. THE FIRST AMERICAN GAS MASK. FIG. 9. THE MOUTH PIECE AND NOSE SNUBBERS IN PLACE.

chlorpicrine, could not be easily removed by chemical means. It was therefore necessary to combine with the chemicals a universal adsorbent, and carbon, because it has this property to an exceptional degree, was chosen for the purpose. In the meantime the British had invented a mask of extraordinary efficiency. The details are given in Figs. 8, 9, 10, 11, 12. Fig. 13 represents an early French type of mask.

THE AMERICAN MASK

When the United States of America entered the World War the newly organized American Gas Defense had on its hands the enormous problem of supplying every soldier who went abroad with an efficient protection against poison gas, and every soldier in the concentration camps at home with a mask for training purposes. The Gas Defense did not wait to develop

FIG. 10. THE MOUTH PIECE AND SNUBBERS. FIG. 11. THE CANISTER STANDING BESIDE ITS CONTAINER.

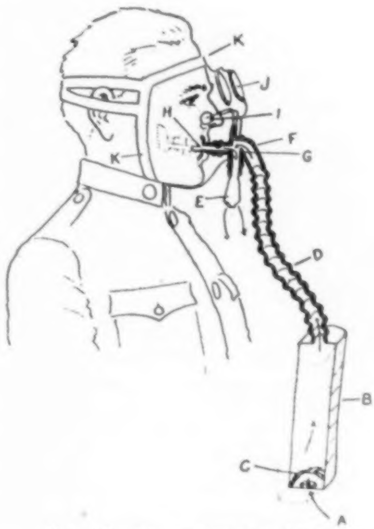


FIG. 12. CROSS-SECTION AMERICAN RESPIRATOR. *A* is the air inlet. *B* is the canister containing granules of soda lime impregnated with sodium permanganate, and carbon granules about one quarter the size of ordinary peas. *D* is a flexible rubber tube the end of which, *H*, is held in the mouth. *E*, is the outlet flutter valve for the exhaled air. *I* represents the nose snubbers. The great virtue of this mask lay in the fact that the soldier could not be gassed as long as he breathed through the tube in his mouth, even if the face piece became punctured or did not fit properly.

an ideal device, but wisely chose to adopt the British type of mask. Incidentally this was a fine tribute to the British scientist, because the mask was much superior to any in use at that time by the European armies. However, American scientists did not rest satisfied with the results of their allies, but on the contrary began to develop the existing devices. It has been said that Americans invent and other nations improve upon the inventions while we are resting on our oars. In this particular instance the tables were turned, for in a few months we were producing carbon for gas masks fifty to one hundred times as valuable as any known to our allies and certainly vastly superior to that which the Germans were using. Equally important advances were made in the soda-lime, and the American mask soon became the object of admiration of both friend and foe. It should be said in justice to German chemists that they too succeeded toward the close of the war in greatly increasing the efficiency of their carbon.

FIG. 13. AN EARLY FRENCH MASK.

DEFECTS OF THE MASK

Every driver of an automobile recalls unpleasant experiences with the fogging or clouding of the wind shield in cold or damp weather. The same problem was met with to an accentuated degree in the gas mask. The

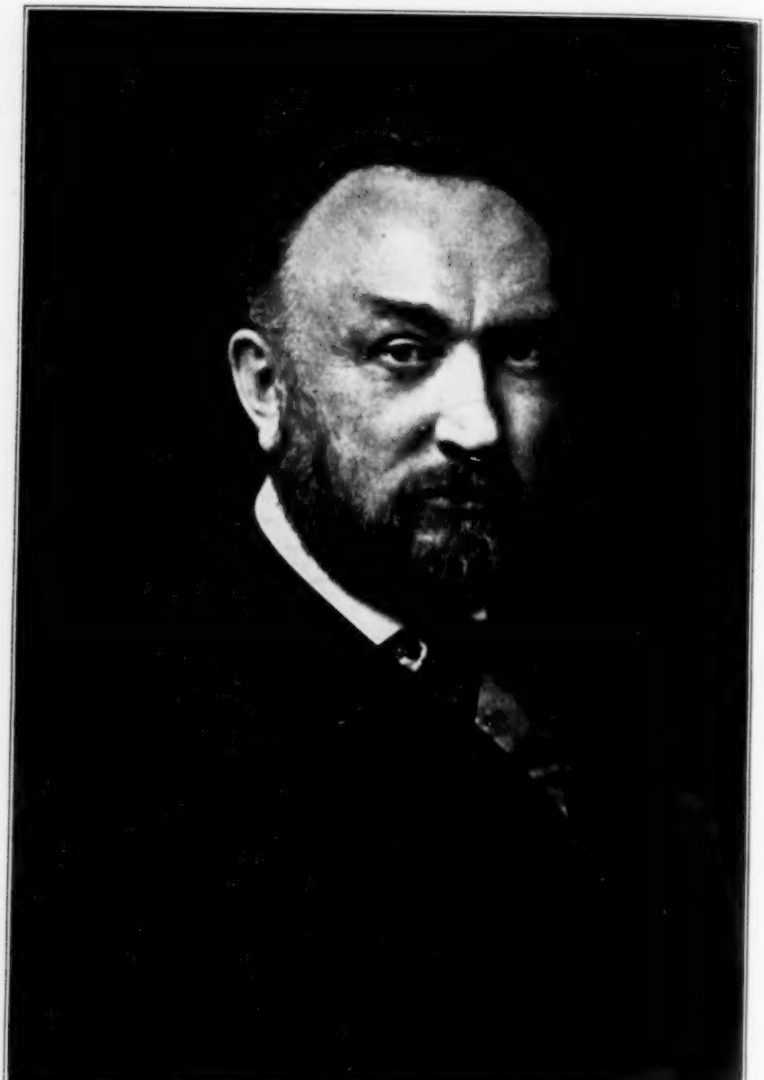
moisture from the breath or even from the eyes condenses on the eye pieces, causing them to fog. In cold weather the condensation is great enough to create droplets that hang suspended or run down in an irregular manner over the surface. The result is distorted and obscure vision. The Germans partially overcame this difficulty by inserting gelatin-like disks on the inside of the eye pieces. Sooner or later the gelatin-like substance becomes soft and sags, so that the vision is imperfect. Several fairly efficient anti-dimming preparations were compounded by American chemists to be applied to the inside of the lenses by the soldier before the mask was required for use. This problem was largely solved in the latest type of American mask by a very ingenious device. The intake manifolds were carried up to a point directly underneath the eye pieces, so that the cold air played on the lenses, keeping them cool on the inside. As a consequence the condensation was reduced to a minimum and anti-dimming compounds were seldom necessary. The nose snubbers and the rubber tube that was held in the mouth in the old mask were eliminated in the new type. This was a boon to the soldier, for he could now breathe in the normal manner through the nose, thus being relieved to a very considerable extent from the discomfort of the old type mask.

Another defect was discovered in the matter of the construction of the eye pieces. All the armies were using celluloid because it would withstand hard usage. It was found, however, that the surface of the celluloid soon became wavy and the resulting uneven vision caused headaches, indigestion and even nausea. For this reason triplex glass that will withstand a severe shock is employed in the latest American mask.

Experience with long-continued wearing of the gas mask in the field proved that the soldier became exhausted. Some interesting and valuable physiological experiments revealed the fact that if one is obliged to breathe against a resistance equivalent to a column of water two to six inches high, an inadequate amount of air is taken into the lungs to oxygenate the blood sufficiently. The resistance offered to the air by the contents of the canister in the American and especially the British masks was much too high. Consequently the soldier when working hard did not get enough air to purify his blood and partial or complete exhaustion resulted. This is believed to have been a large factor in the collapse of the Fifth British army last March. The men had been obliged to wear their masks for days because of the constant bombardment with gas and were exhausted when the Germans finally attacked.

At the close of the war a new type of canister was being produced in America in which the resistance was reduced below the danger point. The new canister was also designed to meet the requirements of the latest developments of gas warfare, the "smoke" problem. Certain substances, such as sulfur trichloride, were used in gas shells to produce, not gases, but very fine particles that remain suspended in the air often for long periods. In the case mentioned the sulfur trioxide unites with moisture of the air to form tiny particles of sulfuric acid. Many of these small particles produced in this or a similar manner were not removed by the contents of any mask in use on the battle field. The latest American canister gives an almost perfect protection against this insidious form of gas warfare.

With regard to gas warfare the American Gas Offense held the same views as their contemporaries in the field. The best kind of defense is to strike back harder than the enemy can. With this end in view enormous quantities of deadly gases, especially phosgene and "mustard gas," were being produced for our army at the close of the war and preparations were nearly completed to increase the production to several hundred tons per twenty-four hours.



Charles Edward Pickering

THE PROGRESS OF SCIENCE

CHARLES EDWARD PICKERING

THE nation and the world are losing the men of science who in the last generation were its leaders. It may be that among their survivors, increased tenfold in numbers, there are ten times as many men of equal ability and performance. That is for the next generation to decide; for us the men who pass away seem to be irreplacable in their work and most of all in the distinction of their personal qualities.

While America was dependent on foreign nations for research in most of the sciences it maintained a certain leadership in astronomy. This appears to have been due to the fact the observatories were endowed here in which opportunities were offered for research, to which scientific men could devote their entire time and energies. Three outstanding astronomers were Newcomb, Hill and Pickering. They worked by diverse methods. Hill on his farm at Nyack was isolated from all organization. Newcomb used the Naval Observatory and was both aided and hampered by the government's provision for astronomical work. Pickering, the head of a college observatory, made in large measure his own opportunities by his remarkable powers of organization.

John Pickering, who settled in Salem in 1642 founded a distinguished New England family; his great grandson, Charles Edward Pickering, was born in Boston in 1846. He died on February 3 in the house of the director of the Harvard College Observatory, active, until stricken by pneumonia, with the work he had conducted for forty-two years.

Pickering became full professor of physics in the Massachusetts Institute of Technology at the age of twenty-two. He there introduced the laboratory method of teaching physics unknown elsewhere and carried on important experimental work on light and on other subjects related to astronomy. In 1877 he was appointed to be the successor of Winlock as director of the Harvard College Observatory.

Pickering devoted himself and the resources of the Harvard College Observatory in large measure to the then undeveloped science of astrophysics, with the fruitful results described in some eighty volumes published by the observatory. Photometric and photographic work was undertaken by new methods and on a scale not before imagined. For example, in a few years three times as many variable stars were detected there as had been discovered in the whole history of astronomy. Two million measurements of the light of 80,000 stars have been made at Harvard, and the results have been the discovery of three fourths of the known 5,000 variable stars. Two telescopes have taken photographs, the plates of which weigh eighty tons. An observatory was established at Arequipa to obtain corresponding results in the southern hemisphere.

The organization of work on such a great scale with extensive equipment and many observers and computers, controlled by one man, was a development of science comparable with the modern organization of industry in America. It does not supersede the need of men such as Hill or Willard Gibbs, but it gives a new and powerful method for the

advancement of science congenial to the genius of organized democracy.

The industrial trusts have obtained control by the suppression of rivals. Here the methods of Pickering were the exact reverse, and set standards which we may hope will ultimately prevail. He not only obtained large endowments for the Harvard Observatory and perfected its methods, but was equally active in assisting and organizing astronomical work throughout the country and the world. He was by common consent the permanent president of the American Astronomical Society. All astronomers and many not astronomers are his debtors for counsel and help. Others will take up and carry forward the astronomical work that Pickering originated and organized. His place as a man with other men will remain unfilled.

A NATIONAL DEPARTMENT OF EDUCATION

A BILL has been introduced in the Senate and the House creating a department of education with a secretary of education and appropriating money for educational work in cooperation with the states. The bill has the support of the National Education Association and the American Federation of Labor. It can not be passed before March 4, but efforts will be made to have the subject considered by the next congress.

Other leading nations have a ministry of education, but here education has been held to be a state function. The present bill is indeed not intended to interfere with the autonomy of the states, but, like the bill that has been adopted to promote vocational education, would distribute money to the states on condition that they appropriate equal amounts for the same purposes. The states and local authorities would retain exclusive administration and control of education within their respective jurisdictions, the federal government exercising supervision only to the extent necessary to see that the amounts appropriated are used by the states for the purposes specified in the bill. The allotments would be paid to the states quarterly and disbursed on the order of the state's chief educational authority, as designated by the state legislature.

The bill authorizes an annual appropriation of $100,000,000, to be apportioned among the states for the following purposes: (1) To encourage the states in the removal of illiteracy, $7,500,000. (2) To encourage the states in the Americanization of foreigners, $1,500,000 (3) To encourage the states in the equalization of educational opportunities, and for the partial payment of teachers' salaries, providing better instruction, extending school terms and otherwise providing equally good schools for all children, $50,000,000. (4) To encourage the states in the promotion of physical and health education and recreation, $20,000,000. (5) To encourage the states in providing facilities for preparing and supplying better teachers, $15,000,000.

In the hearings that have been held before the House education committee, as reported in the New York *Tribune*, striking facts have been brought to light showing the extent to which the illiteracy evil exists in the United States. The selective draft alone brought out the fact that there were 700,000 illiterate males in this country between the ages of twenty-one and thirty-one, unable either to understand the principles for which they were called upon to fight or to read the Constitution they were expected to defend. Altogether, it has been testified by experts, there are at the present

time in the United States 8,592,000 illiterates and persons unable to speak English, of whom 1,006,000 live in New York State and 621,000 in Pennsylvania.

Statistics were presented to show that 62 per cent. of the miners employed in this country are of foreign birth and that thousands of them are not only unable to read safety instructions posted up in the mines, but are unable to understand directions spoken to them in English. This fact is held to be largely accountable for the great number of accidents in the mines, where an average of 3,200 men are killed every year and 300,000, or one third of all those employed, are injured.

Of those examined for military service under the selective service act it was found that more than 700,000 were physically unsound and that a large proportion of the physical defects could have been prevented or removed by proper attention in youth. The economic and industrial loss, not to speak of the poverty and misery, attributable to these facts, experts have testified, has been enormous.

The importance of the problem of Americanization, it is held, has been emphasized repeatedly during the war and is self-evident from the fact that there are now 13,000,000 foreign born in this country. Not only many of these, but many of the native born, the committee has been told, are ignorant of their duties and responsibilities as citizens.

Advocates of the bill insist that it is essential in any form of constructive legislation to meet the illiteracy peril, that provision be made for the government to assist the states in paying adequate salaries to teachers, and that more teachers, well-trained, be provided. Referring to the fact that there are 22,000,000 children of school age in the United States, a brief laid before the House Committee in behalf of the American Federation of Labor, the American Federation of Teachers and the National Education Association said:

The Bureau of Education reports that the average annual salary paid teachers in this country in 1918 was $630.64, which is $243 less per annum than the average wage paid to scrub-women in the United States navy yard. Is there any wonder that results are not always satisfactory? Inefficient schools are almost invariably the result of inadequate support. Low salaries are driving many good teachers out of the profession and filling the ranks with the immature, inexperienced and untrained.

Of the 600,000 teachers in America 100,000 are less than twenty years old; 150,000 have served two years or less; 30,000 have no education beyond the eighth grade; 200,000 have had less than a high school education. Our government has been accused of giving more thought to agriculture and commerce than to education; more attention to livestock than to children.

STORAGE RESERVOIRS IN THE ADIRONDACKS AND WATER CONSERVATION IN NEW YORK

A BULLETIN of the College of Forestry at Syracuse emphasizes the fact that the building of storage reservoirs alone will not solve the flood or water conservation problem in New York. The building of storage reservoirs must be combined with general reforestation.

The present interest in the development of water power in New York is emphasizing the problem of bringing about regular flow in streams for both power and domestic use. There is no question of course but that streams must be kept to a certain level throughout the year to be of value in the production of power. Where a stream fills its banks for a few months of the year and then dwindles to nothing, necessitating

the use of steam power for the remainder of the year, these streams can be said to be of really little value to the state. There is no question but that the building of storage reservoirs at strategic points on water courses will assist in holding water back and allowing the streams to fill to a higher level through a longer period of the year, but the building of these reservoirs is only solving half the problem. If the forests are stripped off, allowing melting snow and rain to rush rapidly to the streams, this flood water will carry soil that will fill the reservoirs as rapidly as they are cleaned out. That this is the result of building reservoirs without proper reforestation of the headwaters of the stream has been videnced repeatedly in the Alps in France and Italy and in our own western mountains in California.

Forests have a marked influence in conserving the water which falls in the form of rain and snow. The branches of the trees break the force of the rain, letting it fall to the ground and pass into the soil easily. The cover formed by decaying leaves and sticks is a sponge-like mass called duff or humus, and this has a great water absorbing capacity. It takes up in proportion to its volume a vast quantity of water and gives it off slowly over a period of several months, thus maintaining springs and even flow in the streams.

General uniformity of stream flow in every section of the country will probably be brought about only as the result of widespread and intelligent reforestation combined with a limited number of large storage reservoirs at the headwaters of streams. If in connection with the reforestation of the barren areas, storage reservoirs are constructed so that the flood waters of spring may be impounded and given off gradually during the dryer seasons of the year, the combination of the two—the forest and the storage reservoirs—will come as near solving the problem of uniform flow in our streams as anything that can be contrived by man. Proper control of runoff is the only thing that will maintain a supply of water in streams upon which manufacturing industries are dependent and insure proper levels for navigation.

While forests act as protectors of the soil and conservers of water, they will be producing a crop of wood that will give increasingly large returns. There are, therefore, both direct and indirect benefits to be obtained from the reforestation of the nonagricultural hillsides and ridges which form so considerable a part of the great state of New York. There should be, therefore, constant cooperation between those who wish to develop the waterpower of the state or cities using water from our forests with the agencies carrying on reforestation. Without proper forest cover there can not be proper water supply.

SCIENTIFIC ITEMS

We record with regret the death of Dr. Brown Ayres, president of the University of Tennessee and previously professor of physics at Tulane University; of Rolla C. Carpenter, professor of experimental engineering at Cornell University; of William Erskine Kellicott, professor of biology at the College of the City of New York, and of Profesor R. Nietzki, professor of chemistry at Bâle.

The gold medal of the National Institute of Social Sciences has been awarded to Dr. Wm. H. Welch, of the Johns Hopkins Medical School. —Dr. J. A. L. Waddell, whose recent articles on engineering fifty years hence will be remembered by readers of this journal, has been elected a corresponding member of the Paris Academy of Sciences.